

REPROGRAMMABLE OPTICAL READER

Cross References to Related Applications

5 This is a continuation of U.S. Patent Application
Serial No. 09/385,597 filed on August 30, 1999, which is a
continuation-in-part of U.S. Patent Application Serial No.
08/839,020 filed April 23, 1997, which, in turn, is a
continuation-in-part of U.S. Patent Application Serial No.
10 08/697,913, filed September 3, 1996, which issued as U.S.
Patent No. 5,900,613 on May 4, 1999, the contents of which are
relied upon and incorporated herein by reference in its
entirety, and the benefit of priority under 35 U.S.C. § 120 is
hereby claimed.

Background of the Invention

Field of the Invention

15 The present invention relates to hand held optical
reading devices, and is directed more particularly to a hand
held optical reading device configured to be controlled with
20 use of a local host processor.

Description of the Prior Art

25 One-dimensional optical bar code readers are well known
in the art. Examples of such readers include readers of the
SCANTEAM® 3000 Series manufactured by Welch Allyn, Inc. Such
readers include processing circuits that are able to read one-
dimensional (1D) linear bar code symbologies, such as the
UPC/EAN code, Code 39, etc., that are widely used in
30 supermarkets. Such 1D linear symbologies are characterized by
data that is encoded along a single axis, in the widths of
bars and spaces, so that such symbols can be read from a

5 single scan along that axis, provided that the symbol is imaged with a sufficiently high resolution along that axis.

In order to allow the encoding of larger amounts of data in a single bar code symbol, a number of 1D stacked bar code symbologies have been developed, including Code 49, as described in U.S. Patent No. 4,794,239 (Allais), and PDF417, as described in U.S. Patent No. 5,340,786 (Pavlidis, et al). Stacked symbols partition the encoded data into multiple rows, each including a respective 1D bar code pattern, all or most all of which must be scanned and decoded, then linked together to form a complete message. Scanning still requires relatively high resolution in one dimension only, but multiple linear scans are needed to read the whole symbol.

A third class of bar code symbologies, known as two dimensional (2D) matrix symbologies, have been developed which offer orientation-free scanning and greater data densities and capacities than their 1D counterparts. Two-dimensional matrix codes encode data as dark or light data elements within a regular polygonal matrix, accompanied by graphical finder, orientation and reference structures. When scanning 2D matrix codes, the horizontal and vertical relationships of the data elements are recorded with about equal resolution.

In order to avoid having to use different types of optical readers to read these different types of bar code symbols, it is desirable to have an optical reader that is able to read symbols of any of these types, including their various subtypes, interchangeably and automatically. More particularly, it is desirable to have an optical reader that is able to read all three of the above-mentioned types of bar code symbols, without human intervention, i.e., automatically. This in turn, requires that the reader have the ability to

5 automatically discriminate between and decode bar code symbols, based only on information read from the symbol itself. Readers that have this ability are referred to as "autodiscriminating" or having an "autodiscrimination" capability.

10 If an autodiscriminating reader is able to read only 1D bar code symbols (including their various subtypes), it may be said to have a 1D autodiscrimination capability. Similarly, if it is able to read only 2D bar code symbols, it may be said to have a 2D autodiscrimination capability. If it is able to
15 read both 1D and 2D bar code symbols interchangeably, it may be said to have a 1D/2D autodiscrimination capability. Often, however, a reader is said to have a 1D/2D autodiscrimination capability even if it is unable to discriminate between and decode 1D stacked bar code symbols.

20 Optical readers that are capable of 1D autodiscrimination are well known in the art. An early example of such a reader is the Welch Allyn SCANTEAM® 3000, manufactured by Welch Allyn, Inc..

Optical readers, particularly hand held optical
25 readers, that are capable of 1D/2D autodiscrimination are less well known in the art, since 2D matrix symbologies are relatively recent developments. One example of a hand held reader of this type which is based on the use of an asynchronously moving 1D image sensor, is described in
30 copending, commonly assigned U.S. Patent No. 5,773,806, which application is hereby expressly incorporated herein by reference. Another example of a hand held reader of this type which is based on the use of a stationary 2D image sensor, is described in copending, commonly assigned U.S. Patent

5 Application Serial No. 08/914,833, which is also hereby
expressly incorporated herein by reference.

Optical readers, whether of the stationary or movable
type, usually operate at a fixed scanning rate. This means
that the readers are designed to complete some fixed number of
10 scans during a given amount of time. This scanning rate
generally has a value that is between 30 and 200 scans/sec for
1D readers. In such readers, the results of successive scans
are decoded in the order of their occurrence.

Prior art optical readers operate relatively
15 satisfactorily under conditions in which the data throughput
rate, or rate at which data is scanned and decoded, is
relatively low. If, for example, the scanning rate is
relatively low and/or the data content of the bar code or
other symbol is relatively small, i.e., the scanner is
20 operating under a relatively light decoding load, the decoding
phase of the reading process can be completed between
successive scans. Under these conditions scan data can be
accurately decoded without difficulty.

Readers of the above-described type have the
25 disadvantage that, if they are operated under relatively heavy
decoding loads, i.e., are required to rapidly scan symbols
that have a relatively high data content, the tracking
relationship or synchronism between the scanning and decoding
phases of the reading process will break down. This is
30 because under heavy decoding loads the decoding phase of a
read operation takes longer than the scanning phase thereof,
causing the decoding operation to lag behind the scanning
operation. While this time lag can be dealt with for brief
periods by storing the results of successive scans in a scan
35 memory and decoding the results of those scans in the order of

5 their occurrence when the decoder becomes available, it cannot
be dealt with in this way for long. This is because, however
large the scan memory, it will eventually overflow and result
in a loss of scan data.

One set of solutions to the problem of maintaining the
10 desired tracking relationship between the scanning and
decoding phases of the reading process is described in
previously mentioned copending U.S. Patent Application Serial
No. 08/914,833. Another set of solutions to the problem of
maintaining the desired tracking relationship between the
15 scanning and decoding phases of the reading process is
described in U.S. Patent No. 5,463,214, which issued on the
parent application of the last mentioned copending patent
application.

Generally speaking, the latter of these two sets of
20 solutions to the above-discussed tracking problem involves the
suspension of scanning for brief periods in order to assure
that the scanning process does not pull too far ahead of the
decoding process. The former of these two sets of solutions
to the above-discussed tracking problem, on the other hand,
25 involves the skipping over of one or more sets of scan data,
in favor of more current scan data, if and to the extent
necessary for tracking purposes, in combination with the use
of two or more scan data memories to minimize the quantity of
scan data that is skipped.

30 Prior to the present invention, no consideration has
been given to accomplishing scan-decode tracking in
conjunction with 1D/2D autodiscrimination, i.e., as
cooperating parts of a single coordinated process. This is in
spite of the fact that the 1D/2D autodiscrimination is known
35 to involve heavy decoding loads of the type that give rise to

5 tracking problems. Thus, a need has existed for an optical reader that combines a powerful tracking capability with a powerful 1D/2D autodiscrimination capability.

As new and/or improved 1D and 2D bar code symbologies, and as additional 1D and 2D decoding programs come into
10 widespread use, previously built optical readers may or may not be able to operate therewith. To the extent that they cannot operate therewith, such previously built optical readers will become increasingly obsolete and unusable.

Prior to the present invention, the problem of updating
15 optical readers to accommodate new bar code symbologies and/or new decoding programs has been dealt with by manually reprogramming the same. One approach to accomplishing this reprogramming is to reprogram a reader locally, i.e., on-site, by, for example, replacing a ROM chip. Another approach to
20 accomplishing this reprogramming is to return it to the manufacturer or his service representative for off-site reprogramming. Because of the expense of the former and the time delays of the latter, neither of these approaches may be practical or economical.

25 The above-described problem is compounded by the fact that, if an optical reader is not equipped to operate as a tracking reader, it may not be possible to reprogram it to use an autodiscrimination program that is designed to be executed in conjunction with tracking. This is because the
30 autodiscrimination program may include steps that require the tracking feature to prevent data from overflowing the scan memory and being lost. Alternatively, the scan rate may be decreased, although this reduction will adversely affect performance when low data content symbols are read. Thus, a
35 need has existed for an optical reader that can be

5 reprogrammed economically in a way that allows it to realize the full benefit of the 1D/2D autodiscrimination and tracking features, among others.

Summary of Invention

10 In accordance with the present invention, there is provided an optical scanning and decoding apparatus and method, suitable for use with bar code readers, bar code scanning engines, and portable data terminals (PDTs), which combines improved scanning-decoding and autodiscrimination
15 features in the context of an apparatus and method which also provides improved menuing and reprogramming features.

In accordance with the menuing feature of the invention, there is provided an improved apparatus and method which enables a user to determine the current operating mode
20 of an optical reading apparatus, and to rapidly and conveniently change that operating mode to optimize it for operation under then current conditions. The menuing feature, for example, enables the user, via a machine readable table of pre-recorded menu symbols, to command the reader to
25 communicate with a host processor using one of a number of protocols, to command the reader to format the decoded output according to host processor requirements, or to command the reader to report to the host processor any of a plurality of types of information about the current operating state of the
30 reader, such as the version of software then being used, the code options that are then being used, and even a complete listing of the reader's parameter table. If a suitable printer is available, the complete status of a first reader may be output as a machine readable menu symbol that other,
35 similarly equipped readers may read and use to reconfigure

5 themselves for operation in the same manner as the first reader.

In accordance with the reprogramming feature of the invention, there is provided an improved apparatus and method by which an optical reader may be reprogrammed from a source
10 external to the reading apparatus, with or without the participation of a user. This external source may be either on-site, i.e., located at the same local facility as the reader, or off-site, i.e., located at a remote facility that is coupled to the local facility only via a transmission line
15 or computer network. When actuated, the reprogramming feature enables a reader to reprogram itself, either in whole or in part, and thereby become able to operate with operating software of the latest type. Depending on the application, the reprogramming of the reader may be initiated either by a
20 host processor external to the reader, as by a command issued via the reader's communication port, or by a user initiated command issued as a part of the above-mentioned menuing process.

In accordance with another aspect of the reprogramming
25 feature, a local host processor may be configured to carry out reprogramming of an optical reader or another type of portable data terminal. In a reprogramming subroutine according to the invention a local host processor can be made, at the selection of a user, to replace an entire main program and parameter
30 table of a reader, or else one of either a main program or a parameter table of an operating program individually.

In accordance with another subprogram of a local host processor, the local host processor can be made to edit a

5 parameter table. When this subprogram is selected the user
may either edit the parameter table that is stored in a memory
device of the reader or else edit a parameter table stored in
a memory device in communication with the local host
processor. After editing, the user may write the edited
10 parameter table to the reader's memory device, write the
edited parameter to the a bulk storage device for later use,
or print or display the edited parameter table.

In accordance with another aspect of the invention, an
optical reader of the invention may be made to receive a
15 component control instruction from a host processor which is
transmitted in response to a user input command to remotely
control an optical reader. In accordance with this aspect of
the invention, the optical reader is made to execute a
component control instruction substantially on-receipt
20 thereof. In one embodiment, execution by an optical reader of
a component control instruction has the same effect as a
reader trigger being manually pulled.

In accordance with the present invention, there is also
provided an optical scanning and decoding apparatus and method
25 which includes improved scanning-decoding and
autodiscrimination features, either or both of which may be
used in conjunction with, and/or under the control of, the
above-described menuing and reprogramming features. In other
words, the autodiscrimination feature of the invention is made
30 available to the user on a menu selectable or reprogrammable
basis to speed up and/or update the decoding phase of the
scanning and decoding process. Together, these features

5 enable the reading apparatus of the invention to read and
decode a wide range of optically encoded data symbols at an
improved data throughput rate.

When a reader is one in which the scan engine cannot be
readily started and stopped, or in which such starts and stops
10 impose unacceptable delays or produce user perceptible
flicker, the present invention preferably operates in one of
the tracking relationships described in previously mentioned
copending Application Serial No. 08/914,833. One of these
tracking relationships is a Skip Scan tracking relationship in
15 which the results of one or more scans may be skipped over
entirely in favor of more recently produced scan results.
Another is a Decode On Demand tracking relationship in which
decoding is suspended briefly as necessary to allow a scan
then in progress to be completed. The latter relationship is
20 ordinarily not preferred, but is still useful when the reader
is such that its scan memory is able to store only two
complete blocks of scan data.

When the reader is one in which the scan engine can
readily be stopped, the present invention may operate in the
25 tracking relationship described in previously mentioned U.S.
Patent No. 5,463,214. With this, "Scan On Demand" tracking
relationship, scanning is suspended briefly as necessary to
prevent scanning and decoding from becoming uncorrelated with
one another.

30 In the preferred embodiment, the reader includes an
algorithm that is able to accommodate any of the above-
described scanning-decoding relationships, among others.
Which of them is actually used will vary from reader to reader
depending upon the size and type of memory and the type of

5 scan engine used thereby, and may be changed from time to time.

The present invention also contemplates and provides for at least one scanning-decoding relationship which does not fall within the meaning of the above-defined tracking
10 relationships. One of these non-tracking relationships is a "One Shot" relationship or mode in which a single scan is followed by a single decoding attempt and then a stoppage. Such scanning-decoding events may be initiated by respective single actuations of a manual trigger. Because of its
15 inherently discontinuous nature, the use of the One Shot mode implies the non-use of any of the above-mentioned tracking modes.

Two other such scanning-decoding relationships are referred to herein as the "Repeat Until Done" relationship or
20 mode and the "Repeat Until Stopped" relationship or mode. With the Repeat Until Done relationship, scanning and decoding operations follow one after another until a successful decode occurs, and are then discontinued. With the Repeat Until Stopped relationship, scanning and decoding operations follow
25 one after another and continue, even after sets of decoded data are stored or output, until instructed to stop by the release of the trigger or by the readers' program. Because of their repetitive nature, the use of Repeat Until Done and Repeat Until Stopped modes are usable both in conjunction with
30 the above-described tracking modes and independently of those tracking modes. As a result, the Repeat Until Done and Repeat Until Stopped modes may be implemented as user selectable non-tracking relationships or as tracking relationships.

5 In embodiments that use the auto discrimination feature
of the invention, there is provided a method and apparatus by
which a plurality of different symbols of a multiplicity of
different types may be scanned and decoded in a manner that is
optimized for a particular application, on either a menu
10 selectable or a reprogrammable basis. When all of the symbols
to be autodiscriminated are known to be 1D symbols, for
example, the data throughput rate may be increased by
structuring the autodiscrimination feature of the invention so
that no attempt is made to decode 2D symbols, or vice versa.
15 When, on the other hand, the symbols to be autodiscriminated
are known to all be of (or all not to be of) a few types,
whether 1D or 2D, the data throughput rate may be increased by
structuring the autodiscrimination feature so that all but a
few (or only a few) 1D and/or 2D symbologies are disabled,
20 i.e., so that no attempt is made to decode them. Other
possible autodiscrimination options include not decoding or
not outputting data for symbols that encode messages that are
too long or too short to be of interest in a particular
application. In accordance with the invention, any of these
25 options may be chosen and changed as necessary to achieve the
highest possible data throughput rate.

Because of the large number of different combinations
of distinct operational states that are made possible thereby,
the apparatus and method of the invention will be seen to have
30 a protean quality that not only makes it usable in a large
number of different applications, but also enables it to
continue to remain so usable as new functions, new bar code
symbologies and new and updated decoding programs are
developed in the future.

5 Description of the Drawings

Other objects and advantages of the invention will be apparent from the following description and drawings, in which:

Fig. 1 is a block diagram of an embodiment of the
10 reading apparatus of the invention which is generic to reading apparatuses which utilize 1D and 2D image sensors;

Figs. 2 and 3 are block diagrams of embodiments of the reading apparatus of the invention which utilize 2D and 1D image sensors, respectively;

15 Figs. 4A, 4B, and 4C are oblique or partially cutaway views of the 2D reading apparatus of Fig. 2;

Figs. 4D, 4E, and 4F are oblique or partially cutaway views of an alternative embodiment of the reader apparatus of Fig. 2;

20 Figs. 4G, 4H, and 4I are oblique or partially cutaway views of another alternative embodiment of the reader apparatus of Fig. 2;

Figs. 5A, 5B, and 5C are oblique or partially cutaway views of the 1D reading apparatus of Fig. 3;

25 Fig. 6A is a flow chart of the main program of the reading apparatus of the invention;

Fig. 6B is a flow chart of a modified main program of the reading apparatus of the invention;

Fig. 7A shows the structure of one embodiment of a menu
30 word or message suitable for use with the program of Fig. 6;

Figs. 7B and 7C are tables showing examples of the usages to which various parts of the menu word of Fig. 7A may be put;

5 Fig. 8 is a flow chart of the menu routine shown in
Fig. 6;

 Figs. 8A - 8D are examples of option symbol selection
charts which may be used with the menuing feature of the
invention;

10 Fig. 9 is a block diagram of a typical system with
which the reading apparatus of the invention may be used;

 Fig. 10A is a flow chart of a loading routine suitable
for use with the invention;

 Fig. 10B is a flow chart of a reprogramming routine
15 suitable for use with the invention;

 Fig. 11A is a flow diagram illustrating a primary
program for a host processor configured for reprogramming of,
and for other interactions with an optical reader;

 Fig. 11B is a flow diagram illustrating a subprogram
20 for reprogramming an optical reader in communication with a
host processor;

 Fig. 11C is a memory map for a memory space having
stored thereon an operating program comprising a main program
and a parameter table;

25 Fig. 11D is a flow diagram for a subprogram executed by
a host processor for editing a parameter table;

 Fig. 11E illustrates an exemplary parameter
configuration screen;

 Fig. 11F illustrates a flow diagram executed by a host
30 processor for simulating the results of applying editing
commands to a decoded message.

 Fig. 12 is a timing diagram which shows the
scanning/decoding relationship used by the prior art;

5 Fig. 13A through 13E are timing diagrams which illustrate various ones of the tracking relationships made possible by the present invention;

Fig. 14 shows examples of memory structures that may be used in implementing the tracking relationships shown in Figs. 10 13A through 13E;

Fig. 15 is a simplified flow chart which illustrates the "Repeat Until Done", "Repeat Until Stopped", and "One Shot" scanning-decoding modes of the invention;

Fig. 16 is a flow chart of one embodiment of the 1D 15 portion of the autodiscrimination program of the invention;

Figs. 17A through 17E are drawings which facilitate an understanding of the flow chart of Fig. 16;

Fig. 18 is a flow chart of one embodiment of the 2D portion of the autodiscrimination process of the invention;

20 Figs. 19A through 19D show representative bar code symbols of types that may be decoded by the reading apparatus of the invention; and

Fig. 20 is a flow chart that illustrates the effect of the code options of the autodiscrimination process of the 25 invention.

Description of the Preferred Embodiments

Referring to Fig. 1 there is shown a block diagram of an optical reader 10. As will be explained more fully later, 30 Fig. 1 shows the basic structures that together comprise the general form of an optical reader that is suitable for use in practicing the present invention, and is generic to optical readers that use 1D image sensors and to optical readers that use 2D image sensors. Similarly, Fig. 2 shows the basic

5 structures that together comprise the general form of optical
readers that use 2D image sensors. Finally, Fig. 3 shows the
basic structures that together comprise the general form of
optical readers that use 1D image sensors. Since the present
invention is equally applicable to readers that use 1D or 2D
10 image sensors, and to readers that use sensors of either type
to read both 1D and 2D symbols, it will be understood that,
except where specifically limited to readers having 2D or 1D
image sensors, the present description refers generically to
readers of any of the types shown in Figs. 1, 2, and 3.

15 Referring first to Fig. 1, the optical reader of the
invention includes an illumination assembly 20 for
illuminating a target object T, such as a 1D or 2D bar code
symbol, and an imaging assembly 30 for receiving an image of
object T and generating an electrical output signal indicative
20 of the data optically encoded therein. Illumination assembly
20 may, for example, include an illumination source assembly
22, such as one or more LEDs, together with an illuminating
optics assembly 24, such as one or more reflectors, for
directing light from light source 22 in the direction of
25 target object T. Illumination assembly 20 may be eliminated,
if ambient light levels are certain to be high enough to allow
high quality images of object T to be taken. Imaging assembly
30 may include an image sensor 32, such as a 1D or 2D CCD,
CMOS, NMOS, PMOS, CID or CMD solid state image sensor,
30 together with an imaging optics assembly 34 for receiving and
focusing an image of object T onto image sensor 32. The
array-based imaging assembly shown in Fig. 2 may be replaced
by a laser array or laser scanning based imaging assembly
comprising a laser source, a scanning mechanism, emit and

5 receive optics, a photodetector and accompanying signal processing circuitry.

Optical reader 10 of Fig. 1 also includes programmable control means 40 which preferably comprises an integrated circuit microprocessor 42 and an application specific
10 integrated circuit or ASIC 44. Processor 42 and ASIC 44 are both programmable control devices which are able to receive, output and process data in accordance with a stored program stored in either or both of a read/write random access memory or RAM 45 and an erasable read only memory or EROM 46.
15 Processor 42 and ASIC 44 are also both connected to a common bus 48 through which program data and working data, including address data, may be received and transmitted in either direction to any circuitry that is also connected thereto. Processor 42 and ASIC 44 differ from one another, however, in
20 how they are made and how they are used.

More particularly, processor 42 is preferably a general purpose, off-the-shelf VLSI integrated circuit microprocessor which has overall control of the circuitry of Fig.1, but which devotes most of its time to decoding image data stored in RAM
25 45 in accordance with program data stored in EROM 46. Processor 44, on the other hand, is preferably a special purpose VLSI integrated circuit, such as a programmable logic or gate array, which is programmed to devote its time to functions other than decoding image data, and thereby relieve
30 processor 42 from the burden of performing these functions.

The actual division of labor between processors 42 and 44 will naturally depend on the type of off-the-shelf microprocessors that are available, the type of image sensor

5 which is used, the rate at which image data is output by
imaging assembly 30, etc. There is nothing in principle,
however, that requires that any particular division of labor
be made between processors 42 and 44, or even that such a
division be made at all. This is because special purpose
10 processor 44 may be eliminated entirely if general purpose
processor 42 is fast enough and powerful enough to perform all
of the functions contemplated by the present invention. It
will, therefore, be understood that neither the number of
processors used, nor the division of labor therebetween, is of
15 any fundamental significance for purposes of the present
invention.

With processor architectures of the type shown in Fig.
1, a typical division of labor between processors 42 and 44
will be as follows. Processor 42 is preferably devoted
20 primarily to the tasks of decoding image data, once such data
has been stored in RAM 45, handling the menuing options and
reprogramming functions, and providing overall system level
coordination. Processor 44 is preferably devoted primarily to
controlling the image acquisition process, the A/D conversion
25 process and the storage of image data, including the ability
to access memories 45 and 46 via a DMA channel. Processor 44
may also perform many timing and communication operations.
Processor 44 may, for example, control the illumination of
LEDs 22, the timing of image sensor 32 and an analog-to-
30 digital (A/D) converter 36, the transmission and reception of
data to and from a processor external to reader 10, through an
RS-232 (or other) compatible I/O device 37 and the outputting
of user perceptible data via an output device 38, such as a
beeper, a good read LED and/or a display 39 which may be, for
35 example, a liquid crystal display. Control of output, display

5 and I/O functions may also be shared between processors 42 and
44, as suggested by bus driver I/O and output/display devices
37' and 38' or may be duplicated, as suggested by
microprocessor serial I/O ports 42A and 42B and I/O and
display devices 37" and 38'. As explained earlier, the
10 specifics of this division of labor is of no significance to
the present invention.

Referring to Fig. 2, there is shown a block diagram of
an optical reader which is similar to that of Fig. 1, except
that it includes optical and/or electrical assemblies and
15 circuits that are specifically designed for use with a 2D
image sensor. Accordingly, the optical and electrical
assemblies and components of Fig. 2 are labeled with the same
numbers used in Fig. 1, except for the addition of the suffix
"-2". For example, image sensor 32-2 of Fig. 2 is a 2D image
20 sensor which corresponds to generic image sensor 32 of Fig. 1,
imaging optics assembly 34-2 of Fig. 2 is a 2D imaging optics
assembly which corresponds to generic imaging optics assembly
34 of Fig. 1, and so on. In other words, corresponding
elements of Figs. 1 and 2 have corresponding functions,
25 although they may have different shapes and part numbers.
Provided that these differences are taken into account,
however, the description of the reader of Fig. 1 is equally
applicable to the reader of Fig. 2, and will not be repeated
herein.

30 One specific practical example of an optical reader of
the type shown in Fig. 2 may be constructed using the
particular commercially available solid-state integrated
circuits listed in the following component table:

35

COMPONENT TABLE - Fig. 2

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Block Diagram Item	Manufacturer/Part Number
Image Sensor 32-2	VVL 1060B+
Prog. Gate Array 44-2	Actel 814V40A
Microprocessor 42-2	IDT 3081
EROM 46-2	Intel 28F400VB-B60
RAM 45-2	Toshiba TC51V4265DFT-60

Referring to Fig. 3, there is shown a block diagram of an optical reader which is also similar to that of Fig. 1, except that it includes optical and/or electrical assemblies and circuits that are specifically designed for use with a 1D image sensor. Accordingly, the optical and electrical assemblies and components of Fig. 3 are labeled with the same numbers used in Fig. 1, except for the addition of the suffix "-3". For example, image sensor 32-3 of Fig. 3 is a 1D image sensor which corresponds to generic image sensor 32 of Fig. 1, imaging Optics assembly 34-3 of Fig. 3 is a 1D imaging optics assembly which corresponds to generic imaging optics assembly 34 of Fig. 1, and so on. Provided that these differences are taken into account, however, the description of the reader of Fig. 1 is equally applicable to the reader of Fig. 3, and will not be repeated herein.

One specific practical example of an optical reader of the type shown in Fig. 3 may be constructed using the particular solid-state circuits listed in the following component table:

COMPONENT TABLE - Fig. 3	
Block Diagram Item	Manufacturer/Part Number

Image Sensor 32-3	Toshiba 1201
Prog. Gate Array 44-3	Welch Allyn 21203276-01
Microprocessor 42-3	Motorola HC11
EROM 46-3	Atmel AT 29C257
RAM 45-3	Sony CXK 5864-BM-10LL

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Significantly, the above-mentioned structural correspondences between Figs. 1, 2, and 3 should not be confused with the types of symbols that may be read thereby. More particularly, the 2D embodiment of Fig. 2 may be used to scan and decode both 1D and 2D bar code symbols. This is because both types of symbols can be imaged by a 2D image sensor. Similarly, the 1D embodiment of Fig. 3 may also be used to scan and decode both 1D and 2D bar code symbols. This is because a 1D image sensor may be used to image a 2D bar code symbol, provided that it is physically moved thereacross during the course of a scan. Because imaging of the latter type is described in detail in copending U.S. Patent Application Serial No. 08/504,643, which has been incorporated by reference herein, that type of imaging assembly will not be discussed again in full herein.

The reader structures shown in Fig. 2 are preferably supported on one or more printed circuit boards (not shown) that are, in turn, supported within a housing.

Examples of types of housings which may be employed to house elements of the reader apparatus shown in Fig. 2 are shown in Figs. 4A-4I. Figs. 4A-4C show a first exemplary housing 50-2-1, Figs 4D-4F show a second exemplary housing 50-2-2, while Figs. 4G-4I show a third exemplary housing 50-2-3. Housings 50-2-1, 50-2-2, and 50-2-3 are preferably shaped so

5 as to fit comfortably into a human hand, and to include a
finger actuatable trigger, 52-2-1, 52-2-2, 52-2-3. Housing
50-2-3 is shown as having an auxiliary trigger 52-2-3' which
may supplement or replace trigger 52-2-3. Housings 50-2-1 and
50-2-2 have extending therefrom multiconductor cable or tether
10 54-2-1, 54-2-2, for providing communication with a local host
processor, whereas 50-2-3 housing has extending therefrom an
antenna 55-2-3 for providing a communication with a local host
processor. It is seen further that housings 50-2-2 and 50-2-3
have incorporated therein displays 56-2-2, 56-2-3, for
15 displaying information to a user, and a keyboard 58-2-2, 58-2-
3, for inputting data and commands to processor 40.

20 Figs 5A - 5C show a housing 50-3 suitable for housing a
1D reader apparatus of the type described with reference to
Fig. 3. Housing 50-3 includes a finger-actuatable trigger 52-
3 and has extending therefrom a cable 54-3 for providing
communication with a local host processor. Although not shown
as containing such features, it is understood that housing 50-
3 could readily be modified to include a display and a
keyboard similar to those of 2D reader housings 50-2-2 and 50-
25 2-3.

Main Program

The overall operation of the reader of Fig. 1 will now
be described with reference to the flow chart of Fig. 6A. As
30 will be explained more fully presently, Fig. 6A comprises a
high level flow chart which illustrates the preferred
embodiment of the main program of a reader which uses the
apparatus and method of the invention. By "main program" is
meant the program that illustrates the relationships between
35 the major subdivisions or subroutines that together implement

5 the above-described features of the invention. It also means
the program that illustrates the overall flow and sequence of
operations that are responsible for the advantages produced by
the invention. Because Fig. 6A depicts the operation of two
processors 42 and 44, however, operations that appear to be
10 occurring sequentially may actually be occurring
"simultaneously". Processor 44 may, for example, be imaging
and storing newly scanned blocks of image data in RAM 45 while
processor 42 is decoding blocks of image data that were stored
in RAM 45 during earlier scans. This is possible because the
15 two processors are operating in different memory spaces, in
different time slots, or under the common control of a bus
arbitration device. As a result, while the processors can
never use the same memory or address space at the same time
for conflicting purposes, they can be made to execute their
20 respective programs sufficiently cooperatively and
contemporaneously that they are effectively operating
simultaneously. It is in this sense that the word
"simultaneous" will be used herein.

Referring to Fig. 6A, the main program begins with
25 block 605 which causes the reader to wait in a low power state
until trigger 52 is pulled. When the trigger is pulled, the
processor is directed to block 610, which causes it to power
up and initialize the reader hardware, including the ASIC, the
DMA channel and the I/O devices, among others. The processor
30 is then directed to blocks 615 and 620 which cause it to
define the image data memory space that will be used (block
615) and to initialize the reader with the default values of
the operating parameters stored in the parameter table thereof
(block 620).

35 The parameter table, which is preferably stored in EROM
46, specifies the values of the parameters that define the

5 mode in which the reader will operate. Examples of these
parameters include the size and the frame rate of the image
sensor, the codes that will be enabled during
autodiscrimination, the I/O communication protocols, beeper
pitch or volume, among others. The default values of these
10 parameters are those which will be used if the user or an
externally generated reprogramming command does not specify
other values, and correspond to a combination of parameters
which are suitable for use under most operating conditions.
The different parameters that may be used with the invention,
15 and the effect that they have on the operation of the reader
will be discussed in detail later.

After the reader has been initialized, the processor
proceeds to blocks 625 and 627, which call for it to capture
and attempt to decode an image of the target symbol. This
20 involves the performance of a number of related steps, the
particulars of which are determined by the parameters of the
parameter table. Included among these steps are a scanning
subroutine which specifies the address space or spaces in
which scan data will be stored and whether scanning is to be
25 continuous (e.g., at a full video rate, such as 30 frames per
second), or discontinuous (e.g., with pauses related to the
current state of the trigger). The operation of the decoding
routine, which is executed in a user or factory selectable
relationship to the scanning routine, is governed by
30 parameters which control the codes which are enabled for
processing as a part of the autodiscrimination process,
whether decoding is to be continuous or discontinuous, etc.
As will be explained more fully later, permitted combinations
of scanning and decoding parameters together define the
35 scanning-decoding relationships or modes which the reader will
use.

5 After exiting block 627, the processor is directed to
block 630 which, if the decoding attempt was not successful,
is directed back to block 625 unless the trigger has been
released (block 635) or unless reprogramming request has been
received (block 640), or unless a stop or no-repeat request is
10 called for by the current operating mode of the reader (block
642). The loop defined by blocks 625-642 will be the path
repeatedly followed by the processor when autodiscrimination
sequences are performed unsuccessfully, and no menuing or
programming changes are called for, and no stop request is in
15 effect. If this loop is interrupted by the user's release of
the trigger, or by a successful decode, or by a reprogram
request, or by a stop request, the reader will be directed by
block 635 to stop and wait in a low power state until further
processing is called for.

20 In the above-described loop, block 642 serves the
function of stopping the repetitive scanning and decoding of
the target symbol in those scanning-decoding modes or under
those conditions in which a repetition of scanning and/or
decoding is not called for. In the One Shot mode, for
25 example, scanning and decoding are discontinued after one
decoding attempt, whether or not that attempt is successful,
without regard to the state of the trigger. Similarly, in the
Repeat Until Stopped mode, scanning and decoding may be
discontinued either by command, via block 642, or by the
30 release of the trigger via block 635. Thus, block 642
comprises at least a part of the means by which the reader
gives effect to the scanning-decoding parameters of the
parameter table.

If block 630 indicates that the last decoding attempt
35 was successful, the processor is directed to a block 645 which
calls for a determination of whether the result of the

5 decoding indicates that the decoded symbol was or was not a
menu symbol. This determination may be made on the basis of
results of the decoding, because all menu symbols are encoded
with data that identifies them as such during decoding. If
the decoded symbol is not a menu symbol, it is known that the
10 symbol contained data that is to be output by the reader. In
the latter event, the processor is directed to block 646,
which causes it to output the data and, proceed to block 647.

Block 647, like block 642, comprises part of the means
by which the reader gives effect to the scanning-decoding
15 modes called for by the parameter table. In particular, if
decoding is successful (block 630) and has been output (block
646), block 647 discontinues scanning and decoding if the
Repeat Until Done mode is in effect. If any other mode is in
effect, scanning and decoding will continue unless blocks 635,
20 640 or 642 call for a different result.

If the decoded symbol is a menu symbol, block 645
directs the processor to perform the menuing routine called
for by block 660 before returning to block 635. As will be
explained more fully later in connection with Fig. 8, the
25 latter routine enables the user to command the reader to
perform any of a variety of different tasks, several of which
include making user specified changes to the parameter table,
thereby changing the operating mode of the reader, and the
performance of any of a variety of user specified vector
30 processing routines that do not change the parameter table.
Once either of the latter tasks have been performed, the
reader is directed to block 635, which causes it to capture
and attempt to decode another image, in accordance with the
parameters indicated by the parameter table, unless instructed
35 to the contrary by blocks 635, 640 or 642. Optionally, the
execution of menu routine 660 may be followed by a direction

5 back to block 647, as indicated by dotted line 648, and the resultant discontinuation of scanning and decoding, if the reader is in its Repeat Until Done mode.

While reprogramming request block 640 has been described as being located between blocks 635 and 625, it
10 actually preferably represents an externally generated interrupt request that may occur at any time that the reader is operating. Such a request may, for example, be initiated by a local host processor via one of I/O devices 37, 37' or 37". It may also be initiated by a remotely located
15 processor, via one of the latter I/O devices, through a suitable transmission line or computer network, as shown in Fig. 9. However the reprogramming request is initiated, it directs the reader to execute the reprogramming routine called for by block 670. As will be explained more fully in
20 connection with Fig. 10A, this routine causes the reader to be reprogrammed, either in whole or in part, thereby changing or updating the manner in which it operates and/or the symbols which it attempts to decode.

25 Menuing

The menuing feature of the present invention will now be described with reference to Figs. 7A-7C, and the menuing flow chart shown in Fig. 8.

Turning first to Fig. 7A, there is shown the format for
30 a menu message or word 650 of the type used by the present invention. This menu word will ordinarily be produced as a result of the decoding of a menu symbol, selected by the user, from a collection of menu symbols printed in a User's Manual

5 supplied with the reader, along with a description of their functions.

Menu word 650 begins with a first one-byte product identification (ID) code field 650-1 that identifies the type and/or model number of the reader. If the decoded product ID
10 code indicates that it is compatible with the menuing program, execution of the menuing program continues normally. If it is not, the processor is caused to exit the menuing routine without making any menu specified changes.

The next field 650-2 of menu word 650 specifies the op
15 code thereof in terms of a number from 0 to 7. This field specifies the operation to be performed by the menu word. The meanings of these different op codes are listed in Fig. 7C. Among these is op code "0", an op code that specifies some task that does not involve a direct change to the parameter
20 table. Such operations will hereinafter be referred to as "vector processing operations". Exemplary ones of the tasks that may be requested pursuant to op code 0 are listed under headings A1-A4 of Fig. 7C, which tasks may be specified and differentiated from one another by the data included in the
25 data fields 650-3 through 650-7 which follow op code field 650-2.

Specifically, the vector processing operations comprise selectable menu routines. Vectors to these routines can be stored in a vector table. The contents of data field 650-3,
30 "offset", is an index to the vector table relative to the base address thereof. If the offset field includes 10 bits, and only five of these bits are used as an index, then 32

5 different vector values will be possible. In this case the remaining 5 bits may be used for data.

The vector processing operations are preferably made selectable to a user by including respective menu bar code symbols in tables in the User's Manual of the reader. The
10 user may then select the desired vector routine by imaging the appropriate symbol. The manner in which such a table is used will be described later in connection with Figs. 8A-8D.

Among the vector processing operations which may be selected under op code 0 are the following. Operation A1
15 calls for the reader to output, i.e., display or print, via the local host processor, or via an on-reader LCD display, the identity of the version of the software currently being used by the reader. Operation A2 calls for the reader to output the current contents of the parameter table. Operation A3
20 calls for the reader to output the code options that are enabled, e.g., the types of symbols that the reader is to attempt to decode during the autodiscrimination process and whether or not a "multiple symbols option" has been enabled. Other options may also be defined as desired.

25 Operation A4 is a particularly powerful and desirable vector processing operation which causes the printer of the local host processor to print a menu bar code symbol that contains all of the information necessary to instruct another reader how it must be programmed if it is to operate in the
30 same manner as the current reader. This, in turn, enables the user to quickly set up the same (or another) reader to operate in a manner that would otherwise require the user to manually select an entire sequence of parameter table values. If it is used to set up other readers, the process of using such a

5 menuing bar code symbol may be thought of as a "cloning"
procedure, since it allows a multiplicity of readers to be
identically configured.

The type of bar code symbol in which the parameter
table is printed must naturally be in a bar code symbology in
10 which the reader is able to both encode (or write) data and
decode (or read) data. Because the parameter table has a data
content which may be too high to be encoded in many 1D
symbologies, the menu symbol encoding the parameter table is
preferably encoded in a 2D bar code symbol. One 2D symbology
15 which is particularly suitable for use in encoding a menu bar
code symbol of the subject type is that developed by Welch
Allyn, Inc. and referred to as the "Aztec" symbology. The
manner in which data is encoded in accordance with the Aztec
symbology is described in detail in copending, commonly
20 assigned U.S. Patent No. 5,591,956, which is hereby expressly
incorporated herein by reference.

In addition to op code 0, menu word 650 also makes
available op codes 1-7, as shown in Fig. 7C. The latter op
codes comprise simple commands, each of which specifies a
25 change that is to be made at a particular part of the
parameter table, using specified data, if required. Assuming
that parameter values are stored as bytes in respective
addresses of the memory that are set aside for use as a
parameter table, offset field 650-3 will comprise an index to
30 the parameter byte relative to the base address of the table.
The data or data mask that is to be used with the specified
offset is specified by the data contained in up to four 8 bit
data fields 650-4 through 650-7 of menu word 650.

5 Referring to Fig. 7C, for example, op code "1"
specifies a "clear" operation. It directs the processor to
the byte of the parameter table that is pointed to by the
offset field, and uses the content of data field 650-4, Data
0, to specify the bit mask that is to be used to specify the
10 bits to be cleared. Op code "6", on the other hand,
specifies a load operation. It directs the processor to the
byte of the parameter table that is pointed to by the offset
field, uses Data 0 as the bit mask for the bits to be changed,
and uses Data 1 as the new data for those bits. Because the
15 use of op codes of this type are known to those skilled in the
art, the use of these op codes will not be described in detail
herein.

In accordance with the invention, the parameter table
is used to specify the operating options that are made subject
20 to the control of the user. Representative groups of such
options are shown as headings A-E of Fig. 7B, together with
some of the options that may be selected under those headings.
One important group of those options are those that are
labeled as "code options" under heading B. Under this heading
25 may be found the parameter table addresses that are set aside
for use in specifying the enabled/disabled states of the
various decoding programs that may be used during the
autodiscrimination process of the invention. The parameter
table addresses corresponding to options B1 and B2, for
30 example, may be set aside for specifying whether all 1D codes
or all 2D codes are or are not to be used in an attempt to
decode an unknown symbol during autodiscrimination.
Similarly, the parameter table address corresponding to option
B3, may specify a particular bar code symbology, such as

5 MaxiCode, that is to be enabled or disabled, i.e., specify
whether the autodiscrimination process is or is not to include
an attempt to find a MaxiCode symbol in an image. In
addition, the parameter table address corresponding to option
B4 may indicate that after decoding, messages that are longer
10 than a specified maximum length or shorter than a specified
minimum length are not to be output. Depending on the
application, this Min-Max length option may be applied on a
symbology dependent basis, i.e., applied so that it is active
with some symbologies, but not with others, or may be applied
15 on a symbology independent basis. Finally, the parameter
table address corresponding to option B5 specifies whether the
Multiple Symbols option of the invention is or is not to be
used. The enablement of this option, which given effect by
block 643 of Fig. 6A, calls for the reader to attempt to
20 decode more than one symbol in the field of view of the reader
without having to acquire multiple images of that field of
view. The types of options selected for inclusion under
heading B will vary from application to application, and the
present invention will be understood not to be restricted to
25 any particular selection of such types.

The inclusion of user selectable code options as part
of the menuing process of the invention has a significant
effect on the overall data throughput rate of the reader,
i.e., on the time necessary to decode a symbol whose symbology
30 is not known in advance. If, for example, it is known that
none of the symbols to be read during a series of readings
comprise 1D symbols of any type, or any subset of 1D symbols
such as Codabar, Code 39 or Code 128, code options allow a
user to direct that any attempt to decode an unknown

5 symbology according to these symbologies is to be skipped,
thereby shortening the total time necessary for the processor
to decode the unknown symbol according to the symbology which
it does use. This skipping also reduces the chances of a
misread. If, on the other hand, it is known that all of the
10 symbols to be read during a series of reading operations are
of one type, such as Interleaved 2 of 5, all 2D decoding
programs and all the decoding programs for 1D symbologies
other than interleaved 2 of 5 may be disabled, thereby
limiting all decoding attempts to a single 1D symbology.
15 Thus, the menuing process of the invention allows the
autodiscrimination process of the invention to be optimized so
as to achieve the highest possible data throughput rate.

A second important group of options provided by the
menuing process of the invention are those that are labeled as
20 "Scanning-Decoding" Options under heading C of Fig. 7B.
Unlike the code options of heading B, the scanning-decoding
options of heading C are not concerned with which codes are
enabled or disabled, but rather with the relationships which
will be allowed to exist between scanning and decoding. The
25 parameter table address corresponding to option C1, for
example, may be used to specify that the reader operate in a
"One Shot" scanning-decoding mode. In this "One Shot" mode
the reader will scan and attempt to decode one bar code symbol
each time that the trigger is depressed and then stop. The
30 address spaces corresponding to scanning-decoding modes C2 and
C3, on the other hand, may be used to specify that the reader
operate in a "Repeat Until Done" (RUD) or "Repeat Until
Stopped" (RUS) scanning-decoding mode. In these modes, the
reader will scan repeatedly and attempt to decode repeatedly

5 until there is a successful decode (RUD), or until requested
to stop whether or not there is a successful decode (RUS).
Scanning-decoding modes C1 - C3 are preferably made user
selectable by including suitable menu symbols in the User's
Manual.

10 Also included among the scanning-decoding modes of the
invention are the tracking modes listed under headings C4 - C6
of Fig. 7B. Of these, the Scan On Demand (SOD) mode C4, when
enabled, causes decoding to proceed continuously while
scanning is started and stopped as necessary to maintain a
15 tracking relationship between scanning and decoding. Skip
Scan (SS) scanning-decoding mode C5, when enabled, causes the
results of older scans to be discarded in favor of more
current scans when and as necessary to maintain the desired
tracking relationship between scanning and decoding
20 operations. Finally, Decode On Demand (DOD) scanning-decoding
mode C6, when enabled, causes scanning to proceed continuously
while decoding is started or stopped as necessary to maintain
a tracking relationship between scanning and decoding. The
particular one of these tracking modes that will be used is
25 preferably set during manufacture, based on the amount of
image data memory that is present within the reader, and not
changed thereafter. There is no reason in principle, however,
why tracking options C4 - C6 cannot be made user selectable
as, for example, by the inclusion of suitable menu symbols in
30 the User's Manual.

The availability of the SOD, SS and DOD tracking modes
among the scanning-decoding options that may be selected
during the factory programming of the reader is beneficial
since it allows the data throughput rate of the reader to be
35 optimized in view of the amount of memory that is available

5 within the reader. At the same time, because operation in all
of these modes may be disabled during operation in the One
Shot, Repeat Until Done, or Repeat Until Stopped modes, the
reader is able to operate in accordance with the non-tracking
variants of these modes when such operation is preferred. One
10 condition under which such operation may be preferred is one
in which scanning while decoding is slow as a result of the
time sharing of a bus. Thus, the reader of this invention
combines flexibility of use with time-optimized use of the
scanning and memory resources of the reader.

15 As will be explained more fully later, the RUD and RUS
modes may be used either with or without one of the above-
described tracking modes. This is because repetition is a
necessary but not a sufficient precondition to the use of the
tracking modes of the invention. Accordingly, if the RUD or
20 RUS mode is not used in conjunction with a tracking mode it
will comprise a non-tracking mode. If the RUD or RUS mode is
used in conjunction with a tracking mode it will comprise a
tracking mode.

25 Other groups of options that are provided by the
menuing feature of the invention include those that are set
aside under headings A, D and E of Fig. 7B. Of these
Communication Options, heading A, is associated with parameter
table addresses that correspond to various communication modes
that may be used by the reader. Included among these options
30 are A1, an option that enables/disables RS-232 communication
through an I/O device (such as I/O 37, 37', etc.), A2 which
specifies the baud rate of the selected communications mode,
and A3 which enables/disables the RF link that the reader may
use in place of multi-conductor cable 54-2 of Figs. 4A - 4C.
35 Option A4 is an example of a network option which specifies

5 the type of computer network with which the reader is to
operate, in this case ETHERNET, although other types may also
be provided for.

Similarly, heading D is associated with parameter table
addresses that correspond to various miscellaneous operating
10 options that may be selected by the user. Included among
these options are D1 which enables/disables the beeper and
allows the volume thereof to be adjusted, D2 which enables/
disables the use of an aiming LED, and D3 which
enables/disables the provision of aural feedback to the user,
15 among others. An example of a reader which provides aural
feedback is described in U.S. Patent No. 5,420,409.

Heading E is associated with parameter table addresses
that correspond to various transmission options that may be
selected by the user. Included among these options are E1 and
20 E2, which enable/ disable the outputting of check characters
or checksum data with decoded data, and E3 which enable data
edit options such as adding a carriage return and/or a line
feed and/or other ASCII characters to the decoding data.
Options E1 and E2 are useful, for example, in the localization
25 and identification of hardware or software failures during the
servicing of the reader. Option E3 is useful in placing
decoded data in a form suitable for use with an application
program.

Heading F is associated with parameter table addresses
30 that correspond to various message editing commands for
editing the form of characters in a decoded message. These
commands may be, for example, search and replace commands
(option F1), commands to insert characters (option F2),
commands to delete characters from a decoded message (option
35 F3), or other commands.

5 Heading G, meanwhile, is associated with parameter
table addresses that correspond to commands for adding
prefixes or suffixes, of a selectable character length, to a
decoded message. Prefixes and suffixes are added to messages
so that the host processor can identify the source of, or
10 other characteristics of received messages. Option G1 allows
addition of a prefix to a decoded message while option G2
allows addition of a suffix to a decoded message.

 In view of the foregoing, it will be seen that the
menuing process of the invention provides a wide range of user
15 selectable functions and modes that allow the reader to be
tailored to a user's specific application and/or preferences.
Among these, the code options and the scanning-decoding
options in particular, allow a user to reconfigure the
operation of the reader in ways that have not heretofore been
20 possible and thereby substantially increase the flexibility
and overall data throughput rate of readers that practice the
present invention.

 The manner in which the invention can be updated to
accomplish the above-described results will now be described
25 with reference to the flow chart of Fig. 8, which shows the
steps included within menu routine block 660 of Fig. 6A. The
menu routine of Fig. 8 begins with a block 805 which causes
the processor to convert the decoded menu symbol message into
hexadecimal form. This has the effect of formatting the
30 message so that the fields of the menu word are expressed as
pairs of hexadecimal digits. Once this has been done the
processor examines the product ID code to verify that it is
compatible with the reader being menued. If it is not, the
processor is directed to exit the menuing routine and continue
35 scanning. If it is, the processor is directed to block 810

5 which distinguishes those menu messages which contain op codes from those which contain numerical data but no op codes. If there is no op code, the processor is directed to block 815, which causes it to collect in an accumulator all of the digits of the message for later use before proceeding to block 850.

10 An example of numerical data without an op code comprises the minimum or maximum length of the messages that are to be output under code option B4.

If the menu message contains an op code, and the op code is other than 0, the processor is directed, via block 15 820, to a block 825. The latter block causes it to make the parameter table changes called for by the op code and the associated offset and data fields, sets a "flash" flag to indicate that changes have been made and then proceeds to block 850. This has the effect of implementing the user 20 selected changes in the menuing options discussed previously in connection with Fig. 7B. Such changes will ordinarily be made in a copy of the parameter table that is stored in RAM 45, and then later transferred to EROM 46.

If the menu message contains an op code of 0, the 25 processor is directed, via block 820, to a block 830. The latter block causes the processor to perform the vector processing operation indicated by the remainder of the message. This operation will comprise one of the operations discussed previously in connection with items A1-A4 of Fig. 30 7C, among others, before proceeding to block 850.

In view of the foregoing, it will be seen that, when the processor arrives at block 850 it will have taken all required numerical data, performed all required parameter table modifications, or performed all required vector 35 processing operations. As will now be explained, the

5 remainder of the flow chart of Fig. 8 is directed to storing a semi-permanent copy of the parameter table in EROM 46.

If, on arriving at block 850, the processor finds that the "flash" flag has not been set, it knows that the contents of the parameter table have not been changed and,
10 consequently, that no updated copy thereof needs to be stored in EROM 46. Under this condition, the processor is directed to simply return to the main program of Fig. 6A. If, on arriving at block 850, the processor finds that the "flash" flag has been set, however, it knows that the contents of the
15 parameter table have been changed and, consequently, that an updated copy thereof needs to be stored in EROM 46. Under this condition, the processor is directed to blocks 855, 860 and 865, which defines the steps necessary to store this updated copy.

20 In accordance with block 855, the processor is instructed to copy from EROM 46 to RAM 45, the program instructions (flash routine) necessary to copy the parameter table from RAM to EROM. The copying of the flash routine to RAM is necessary because the EROM cannot be written to when
25 the apparatus is reading or operating from the EROM. Once the flash routine has been copied to RAM 45, the processor is directed to jump to RAM to begin executing that routine. As it does so it is directed, via block 860, to erase the old (unchanged) parameter table from EROM 46. Per block 865, it
30 then copies new (changed) parameter table from RAM 45 to EROM 46. Once this has been done, the processor is directed back to the main program of Fig. 6A to begin operating in accordance with the operating mode specified by its new parameter table. Thus, the performance of the steps called
35 for by blocks 855-865, when called for by block 850, has the

5 effect of partially reprogramming the reader so that it
operates in the manner indicated by the last menuing symbols
selected by the user.

Referring to Figs. 8A-8D, there are shown examples of
menu symbol selection charts of the type that may be used with
10 the present invention. Referring first to Fig. 8A, there are
shown two parts of an option selection or menu chart that is
used to enable and disable two exemplary 1D bar code
symbolologies, namely: Code 128 and UPC A. If a user wants to
enable the decoding of Code 128 symbols, he need only image
15 menu symbol 802 which, in the present example, is a 2D bar
code symbol expressed in the Aztec bar code symbology.
Conversely, if a user wants to disable the decoding of Code
128 symbols, he need only image menu symbol 804. Similarly,
imaging symbols 806 or 808 enables or disables the decoding of
20 UPC A symbols. Advantageously, the change called for by the
user is accomplished as the result of a single imaging step,
rather than as a result of multiple imaging steps.

Referring to Fig. 8B, there are shown two parts of an
option selection chart that is used to select the desired one
25 of the baud rates that may be used by the reader's I/O
devices. A user chooses the desired one of the exemplary
1200, 9600, 19200 and 38400 baud rates by simply imaging the
corresponding ones of menu symbols 812-818. Again, the change
is accomplished as the result of a single imaging step.

30 The fact that the above-discussed examples of menu
selections make use of menu symbols that use the Aztec 2D
symbology is not essential to the practice of the invention.
Other 2D or 1D menu symbol symbolologies could also have been
used, if desired, as will be seen from the following
35 discussion of Figs. 8C and 8D. What is important is that the

5 symbology used for the menu symbols be the one that is correct
for the model indicated by the product ID field of the menu
word. In the case of Figs. 8A and 8B, the illustrated menu
symbol symbology is that which is used by the IMAGETEAM™ Model
4400 reader manufactured by Welch Allyn, Inc.

10 Referring to Fig. 8C, there are shown exemplary parts
of the option selection or menu chart that can be used with
Welch Allyn SCANTEAM® readers. In Fig. 8C, symbol 822 is an
example of a menu symbol that, if imaged, causes all Code 11
and Code 128 settings to assume their default values. Symbols
15 824 to 836 are examples of menu symbols that allow Code 11
options to be enabled and disabled on an individual basis.
Similarly, symbols 848 to 856 are examples of menu symbols
that allow Code 128 options to be enabled and disabled on an
individual basis.

20 Referring to Fig. 8D, there are shown further exemplary
parts of the option selection or menu chart that may also be
used with Welch Allyn SCANTEAM® readers. In Fig. 8D symbol
858 is an example of a menu symbol that, if imaged, causes the
settings for one of the RS-232 ports of the reader to assume
25 their default values. Symbols 862 and 864 are examples of
menu symbols that enable and disable a CTS check selection
feature. Finally, symbols 866 through 884 are examples of
menu symbols that allow any of a number of different baud rate
selections to be made. Once again, the present invention
30 allows all of these menu selections to be made by means of a
single step selection process.

Because fuller information concerning the menu options
contemplated by the present invention, and their uses is
contained in the User's Manual for the above-identified

5 readers, these menu options will not be discussed further
herein.

Reprogramming

10 In accordance with another feature of the apparatus and
method of the invention, the reader may be reprogrammed to
operate in accordance with an entirely new application
program. This means that the reader may not only be provided
with a new or updated decoding program, or a new parameter
table, it may also be provided with one or both of a new
15 menuing routine and a new main program. As a result, a reader
may be effectively reconfigured as a new reader, with new
capabilities and features, as often as necessary to keep it up
to date with the latest developments in optical reader
technology. Advantageously, this reprogramming may be
20 accomplished either locally as, for example, by a local host
processor equipped with a diskette or CD-ROM drive, or
remotely by a distant processor that is coupled to the reader
via a suitable telephone or other transmission line or via a
computer network or bulletin board.

25 The reprogramming feature of the invention will now be
described with reference to the system block diagram of Fig. 9
and the reprogramming flow chart of Fig. 10A. Referring first
to Fig. 9 there is shown a reader 10, of the type shown in
Fig. 4 or 5, which is coupled to a local host processor 900 by
30 means of multi-conductor flexible cable 54. The reader may
also comprise a cordless battery powered reader 10' which is
coupled to a host processor 900 via a suitable RF link
including antennae 905 and 910 and an RF interface module 915.
Host processor 900 is preferably equipped with a display 930
35 by which the results of the previously described vector

5 processing operations may be displayed, and with a printer 940
by which the previously described menuing bar code symbol may
be printed. As used herein, the term "local host processor"
will be understood to include both stand alone host processors
and host processors which comprise only one part of a local
10 computer system.

If the new reader program is available locally as, for
example, on a diskette or CD-ROM, it may be loaded into reader
10 or 10' using a suitable drive unit 920, under the control of
a keyboard 925 and the reprogramming routine shown in Figs.
15 10A and 10B. In addition to drive unit 920, processor is
typically in communication with a read only program storage
device such as a ROM 921 and a read/write storage device such
as a RAM 922. If the new reader program is available at a
remotely located processor 950, it may be loaded into reader
20 10 or 10' through a suitable transmission link 955, such an
electrical conductor link, a fiber optic link, or a wireless
transmission link through a suitable communication interface
960, such a modem. As used herein, the term "transmission
link" will be understood to refer broadly to any type of
25 transmission facility, including an RS-232 capable telephone
line, as called for by communication option A1 of Fig. 7B, an
RF link, as called for by communication option A3 of Fig. 7B,
or a computer network, e.g., ETHERNET, as called for by
communication option A4 of Fig. 7B, although other types of
30 transmission links or networks may also be used. For example,
transmission link 955 could be provided by a coaxial cable or
any other non-RF electromagnetic energy communication link
including a light energy infrared or microwave communication
link. Link 955 could also be an acoustic communications link.

5 Additional communication options include a baud rate option A2 which allows different baud rates to be selected.

The manner in which the reader of the invention may be made to perform any of a variety of different externally specified functions, including reprogramming itself, will now
10 be described with reference to the flow charts of Figs. 10A and 10B. As will be explained more fully presently, the flow chart of Fig. 10A is a flow chart by which a program originating outside of the reader may be loaded into the reader for execution thereby. One example of such an
15 externally originated program is the reprogramming program shown in Fig. 10B. Other examples of such externally originated programs may include diagnostic or test programs, among others.

Turning first to Fig. 10A, this flow chart is entered
20 when the reader receives an externally generated command, such as the six character sequence BBOOTT, which it is programmed to recognize and respond to. This command may be initiated either by a local or a remotely located processor and transmitted to the reader via any of the I/O devices shown in
25 Fig. 1. It may, for example, be initiated by the local host processor via keyboard 945 or by remote processor 950. This command may be given effect as an interrupt request and recognized as such by decision block 1005 of Fig. 10A. It will be understood that while interrupt block 1005 is shown in
30 Fig. 10A, it may in fact be located at any point within the main program of the reader.

Once the BBOOTT command has been received and acted on, the processor enters a loading loop including blocks 1007 through 1020. This loading loop causes the processor to load
35 a program into RAM, one line at a time, in conformity with any

5 suitable communication protocol, until the last line of code is detected via block 1020. When the latter has occurred, the processor is directed to block 1025, which causes it to jump to the newly received program and to begin executing the same before returning to the main program.

10 Referring to Fig. 10B, there is shown an exemplary flow chart for a reprogramming routine suitable for use in reprogramming the reader to operate with new or different decoding programs, and or new or different menuing programs, among others. This program is an example of a program which
15 may be executed as a result of the execution of the loading loop 1007-1020 of Fig. 10A, and which begins to be executed as the processor enters block 1025 of Fig. 10A.

On executing the reprogramming flow chart of Fig. 10B, the device loads the program that is intended to replace all
20 or part of the program currently stored in EROM. This process begins as the processor encounters block 1035, which directs it to wait until a line of externally generated code is received. As each line of code is received, it is first checked for correctness (e.g. checksum), as called for by
25 block 1040 and, if an error is found, sends a negative acknowledgment signal to the sending processor per block 1045. Each time that a correct line of code is received, the flow loops back for additional lines until the last line of the current file has been correctly read, as called for by block
30 1050. Since the last line of the file does not contain program data, and cannot occur until all blocks of program data have been processed, block 1050 will direct the processor to block 1060, unless and until all blocks of program data have been received and stored in EROM 46, and then cause it to
35 return to the main program of Fig. 6A via exit block 1055.

5 If the processor has not exited the reprogramming
routine of Fig. 10B per blocks 1050 and 1055, block 1060 will
cause it to determine if the last received line indicated that
a new block has begun. If it has, the processor is directed
to block 1065, which causes it to erase that new block of EROM
10 before continuing to block 1070 and storing that last received
line therein. If it has not, block 1070 will cause the
processor to store the last received line to the last erased
block of EROM. If this line has been successfully stored, as
determined by block 1075, the processor will acknowledge that
15 fact per block 1077 and loop back for another line.

 If, however, any line of data has not been
successfully stored, block 1075 will direct the processor to a
block 1080 which causes it to output an error message and exit
the program. If the latter occurs, the reprogramming routine
20 as a whole must be repeated. If the latter does not occur,
the above-described process will continue line-after-line,
block-after-block, until the entire file has been successfully
transferred.

 In view of the foregoing, it will be seen that the
25 effect of the reprogramming routine of Fig. 10B is to attempt
to reprogram part or all of EROM 46 as requested, or to
continuing the attempt to do so until it either succeeds or
fails. To the extent that the reader is reprogrammed, it will
effectively become a new or updated reader. This is not only
30 because this reprogramming can not only modify the parameter
table, it can also modify the decoding or other programs
referenced by the parameter table and the menuing program
itself. Thus, the reprogramming feature can not only change
the manner in which the reader operates, it can also change

5 the manner in which the operation of the reader can be
modified in the future.

With the use of the above-described reprogramming
feature, the reader of the invention may be kept current with
the latest available programs that are suitable for use
10 therewith. A user at local processor 900 may, for example,
communicate with remote processor 950, via keyboard 925, and
determine if new programmable features are available. If they
are, he may obtain them from the remote process and download
them locally, or request that the remote processor download
15 them directly to the reader. Alternatively, the remote
processor may initiate the reprogramming of the reader
independently as, for example, pursuant to a service contract
or updating service. It will be understood that all such
embodiments are within the contemplation of the present
20 invention.

Local Host and Reader System Operations

As has been described hereinabove, reprogramming of a
reader may be accomplished with use of a local host processor.
25 This section describes additional features of a system
comprising a local host processor 900 and a reader 10
according to the invention, and more particularly describes
features and additional system operations that are realized by
various interaction between host processor 900 and reader 10,
30 and in certain applications by a host processor 900 that is
not in communication with a reader 10.

A flow diagram illustrating the primary program for
operating a local host processor for use in controlling a
reader is shown in Fig. 11A. By executing block 1102 host
35 processor causes to be displayed on a display monitor 930 a

5 subprogram option screen. The subprogram option screen displays various subprogram options for a user to select. Selection of one subprogram option causes a series of instructions pertaining to that particular option to be executed by local host processor 900. These subprograms of a
10 host primary program controlling local host processor may include, for example, a subprogram for reprogramming a reader; a subprogram for uploading parameter information from a reader to host, or information pertaining to a main program presently operating a reader; a subprogram for instructing a reader to
15 perform self-diagnostic testing; a subprogram for determining the reader's main program revision level; a subprogram for outputting parameter table information, possibly to auxiliary readers; a subprogram for editing parameters of a parameter table; a subprogram for simulating the result of applying
20 editing commands to a decoded message; and a subprogram for displaying barcode symbols for scanning by a reader.

A flow diagram illustrating a subprogram for reprogramming of a reader 10 by control of a local host processor is shown in Fig. 11B. Whereas Figs. 10A and 10B
25 illustrate instructions executed by processor 40 of reader 10 for providing reprogramming of a reader, Fig. 11B illustrates instructions executed by local host processor for providing reprogramming of a reader.

At block 1110 host processor 900 displays a main
30 reprogramming screen on display monitor 930. The main reprogramming screen prompts a user to designate a source for an operating program. The source designated is typically a bulk storage device such as a hard or floppy disk drive but also may be, for example, a RAM or ROM storage device. When
35 the source is selected, host processor 900 displays on display

5 monitor 930 indicators of the operating programs, or files,
that are available in the storage device source selected
(block 1114) and a user selects one of the operating programs.
Some available operating programs comprise entire main
programs and entire parameter tables for loading into reader,
10 whereas other available operating programs include only
parameter tables which may be customized parameter tables
created by a user during execution of a parameter table
editing subprogram.

When a user selects a source for an operating program,
15 and selects a desired operating program, downloading of the
operating program proceeds. At block 1116 host processor
determines whether a reader is connected to the host processor
communications link, normally by serially transmitting a
device detection command to a reader, which has been
20 previously programmed to transmit an acknowledge response
message on the reception of a detection command.

If a reader is connected to host processor 900 then
host processor at block 1118 sends an identification command
to reader 10 which is previously programmed to transmit an
25 identification response on the reception of an identification
command. After receiving the identification response and
comparing the response to the selected operating program at
block 1120 processor at block 1122 determines whether the
reader is of a type which is compatible with the selected
30 operating program. An operating program is compatible with a
reader in communication with host processor if the operating
program is specifically adapted for that reader's unique
hardware configuration. Bar code reader's of various types
have different hardware components including different memory
35 devices, image sensors, input/output devices, and other

5 components. The selected operating program must be in form enabling it to communicate with the particular hardware components of the presently connected reader.

If the selected operating program is compatible with the present reader, the host processor at block 1126
10 determines if the operating program is a parameter-only type operating program or an operating program that comprises a main program and a parameter table. This determination can be made, for example, by reading the contents of a DOC type file which is made to be read by processor 900 when an operating
15 program is read, and which is made to include an identifier as to whether the operating program is of a type which includes a main program and parameter table; by reading the contents of a predetermined address of the operating program which is made to include an identifier as to the type of operating program;
20 or by reading predetermined addresses of an operating program designated for storing a main program and basing the determination on whether instructions are present in the designate addresses.

A memory map for a typical operating program in
25 accordance with the invention is shown in Fig. 11C. When an operating program is stored in a memory device, which may be, for example EROM 46 of reader 10, or a disk drive 920 or other storage device associated with host processor 900 a plurality of first predetermined address locations e.g. 000 to 5000 of
30 the storage device are designated for storing parameters of the main program, while a plurality of second predetermined address locations e.g. 8000 to 9000 are designated for storing instructions of a parameter table. The beginning and end addresses of the parameter table may change from operating
35 program to operating program. However, the parameters of each

5 parameter table are in identical locations with respect to the beginning address.

When host processor 900 determines at step 1126 that the selected operating program includes a main program then program control proceeds to step 1130 wherein processor
10 transmits the contents of the selected operating program into EROM 46 of reader 10. If host processor 900 determines at block 1126 that the selected operating program is a parameter only type operating program then host processor 900 first queries EROM 46 to determine the begin and end address
15 locations of the parameter table of the operating program currently stored in EROM. To this end host processor 900 at block 1130 polls the contents of a vector pointer table 1134 in predetermined address locations of EROM. Described previously herein vector pointer table 1134 comprises the
20 beginning and end addresses of the parameter table. After vector pointer table is polled, host processor 900 stores the address location of the present parameter table, modifies the parameter table address of the selected parameter-only operating table in accordance with the parameter table
25 addresses of the existing parameter table (block 1136) and writes the contents of the parameter table address locations of the modified parameter-only type operating program into EROM 46 (block 1140).

If processor 900 determines at block 1126 that the
30 selected operating program is of the type having a main program and a parameter table, then processor 900 at block 1144 prompts the user whether the user would like to save the contents of a parameter table of the operating program currently stored in EROM 46 of reader 10; that is, utilize the
35 parameters of the current operating program in the operation

5 of a reader that is programmed to have a new main program. If
the user responds affirmatively, then processor 900 reads the
contents of the existing parameter table (block 1150) after
first polling the vector pointer table and then writes, at
block 1152, the contents of the existing parameter table in a
10 predetermined holding address location of a storage device
associated with processor 900 or reader 10.

The selected operating table is then written into EROM
46 at block 1140, line by line, until loading is complete. If
the user had requested at block 1144 to save the contents of
15 the original parameter table (a determination made at block
1153), then processor 900 writes the contents of the parameter
table stored in a holding address location to the appropriate
parameter address locations of EROM at block 1154, after
determining the address locations of the parameter table at
20 block 1156. Referring again to the primary host processor
program shown in Fig. 11A, another subprogram which can be
selected from subprogram option screen displayed at block 1102
is a subprogram for editing a parameter table via host
processor control. An important feature available in this
25 subprogram is that the subprogram allows a user to edit a
parameter table read from a memory location of processor 900
or reader 10 without there being a reader currently in
communication with processor 900, thus improving the
convenience of operation.

30 As discussed previously with reference to Fig. 7B, a
parameter table is used to specify operating options that are
subject to the control of the user. During execution of
instructions of a reader's main program stored in a first
predetermined memory locations of a storage device, parameters
35 of a parameter table, which is stored in a second

5 predetermined set of memory address locations of a storage
device, are called up with use of lookup type instruction as
exemplified by representative lookup instruction (in
pseudocode) 1160 shown in Fig. 11C. Parameters of a parameter
table may be, for example, communications option parameters
10 (subheading A), code option parameters (subheading B),
scanning-decoding option parameters (subheading C), operating
option parameters (subheading D), transmit option parameters
(subheading E), data formatter command parameters (subheading
F), prefix/suffix parameters (subheading G), or other types of
15 parameters.

A flow diagram for a parameter table editing subprogram
is shown with reference to Fig. 11D. At block 1162 processor
900 determines if a reader is in communication with processor
900 in the fashion described previously with reference to
20 block 1116 of Fig. 11B. If a reader is present, processor 900
at block 1166 reads the parameter table presently stored in
EROM 46 (after determining the table's location), along with a
list of analog waveform outputs from another predetermined
memory location from EROM 46. A list of possible types of
25 analog waveform outputs a reader may be configured to generate
allowing the reader to transmit data to various types of
terminals is stored in a predetermined waveform list memory
location. The waveform list memory location may be determined
by querying vector pointer table 1134. A specific one type of
30 waveform output from the list of available outputs is selected
by control of a parameter of parameter table, typically stored
in an address location corresponding to Communications Options
(Heading A) type parameters described previously with
reference to Fig. 7B. Processor 900 at block 1116 stores the
35 parameter table and the list of analog waveform outputs in a

5 temporary storage device associated with processor 900 such as
a RAM.

In the embodiment shown, the parameter table editing
subprogram is configured by default to edit the existing
parameter table stored in EROM of the connected reader if a
10 reader is present. It will be recognized, however, that the
editing subprogram can also be configured to query the user as
to whether the user wishes to edit the parameter table
currently stored in reader EROM 46, or another candidate
parameter table typically stored in a bulk storage device
15 associated with processor 900.

If a reader is not in communication with processor 900,
continuing with reference to the flow diagram shown, then
processor at block 1168 prompts the user to select a reader
for which the user wishes to edit a parameter table and once a
20 type of reader is selected, a default parameter table
associated with that reader type is written in to a temporary
storage device of processor 900 typically provided by a RAM
device.

At the termination of block 1168 or block 1166 if a
25 reader is connected, a parameter configuration screen is
displayed to a user, at block 1169, an exemplary embodiment of
which is shown in Fig. 11E. Typically, a user will edit
certain parameters from the parameter table which the user
wishes to change, and then, when editing is complete, a user
30 will select an available output option from the parameter
configuration screen. The output options available to a user
may include writing an edited parameter table to a connected
reader; writing an edited parameter table to a bulk storage
device; displaying an edited parameter table; or printing an
35 edited parameter table.

5 Until an output option is selected, the user typically
edits various parameters the user wishes to change as shown in
blocks 1170 and 1172. Selection of one parameter type option,
e.g. code or symbology option parameter 1174 causes a
secondary editing screen to appear allowing editing of
10 parameters of the selected parameter type. When editing
pertaining to one or several parameter types is complete then
program reverts back to parameter configuration screen at
block 1169, allowing user to select an output option.

15 If a user selects the write output option (block 1176),
the edited parameter table is written to, or downloaded to
reader EROM in the fashion described previously with reference
to block 1140 of Fig. 11B. If a user selects the store-to-
disc option (block 1178) then the edited parameter table is
written to an address location of a bulk storage device such
20 as a hard drive or floppy disc. If a user selects the display
option (block 1180) then processor 900 causes the complete or
partial contents of the edited parameter table to be printed
on display screen associated with host processor 900. If a
user selects the print option (block 1182) then processor 900
25 causes the complete or partial contents of the edited
parameter table to be printed by a printer device 940 in
communication with processor 900.

 Another output option available to a user is to compare
two or more parameter tables. If this option is selected
30 (block 1184) then the user is requested at block 1186 to
select parameter tables from memory locations (which may be
memory location associated with processor 900 or with reader
10). When parameter tables have been selected, processor 900
at block 1186 compares the selected parameter tables. In
35 general, the comparison is carried out by a compare function

5 applied after an offset between the files is accounted for.
Processor 900 then outputs the results of the comparison at
block 1188, typically by displaying the comparison results on
screen 930, or printing the comparison results using printer
940.

10 One specialized output option of the invention allows
the user to create programming menu symbols whose general
features have described with reference to Fig. 7A-7C, and 8.
The menu symbols created by the output option can be used to
reprogram readers reading the created symbols in accordance
15 with the changes made to a parameter table made during
execution of the parameter table subprogram. Described as a
routine executed during a parameter table editing subprogram,
the menu symbol output option can be conveniently implemented
as a separate subprogram.

20 When a menu symbol output option is selected at block
1189, processor 900 determines at block 1202, by reading a
reader identifier, whether the reader designated for receipt
of the edited parameter table includes a one dimensional (1D)
or two-dimensional (2D) image sensor.

25 If the reader includes a one dimensional image sensor,
then processor 900 creates a series of linear bar codes which
may be used for reprogramming several readers. Specifically,
if the designated reader includes a one dimensional image
sensor then processor 900 at block 1204 creates a first linear
30 menu symbol adapted to generate an instruction causing the
reader reading the symbol to change parameter table values of
the reader's EROM to default values. Then, at block 1206
processor 900 creates a distinct linear programming menu
symbol for each parameter of the parameter table that is
35 changed during the editing process from a default value. An

5 important feature of the invention is described with reference
to block 1208. When the series of menu symbols is created,
the created symbols may be printed on paper by printer 940
according to a conventional protocol, or else displayed on
display device 930, typically a CRT monitor. The term created
10 symbols herein refers to binary encoded data stored in a
memory space which result in an actual symbol being output
when the data is written to a display device or printer. An
unlimited number of bar code readers may be reprogrammed by
reading the menu symbols that are displayed on the display
15 device 930. Displaying the created menu symbols on a display
device allows rapid output of created symbols and eliminates
the need to supply a paper substrate each time a menu symbol
is output.

20 If the reader designated for reprogramming includes a
2D image sensor, then processor 900 at block 1210 need only
create one 2D menu symbol in order to cause reprogramming of
the designated reader in accordance with the changes made to a
parameter table even in the case where multiple changes to the
25 parameter table are made. This is so because an increased
number of instructions may be encoded in a symbol of a 2D
symbolology type.

Another subprogram which may be selected from a
subprogram option screen displayed at block 1102 is a
30 subprogram for simulating the result of applying editing
commands to a decoded message. As discussed previously,
editing commands may be applied to decoded messages by entry
of the commands to a parameter table in parameter table
addresses corresponding to heading H of Fig. 7B. Without an
35 editing command simulation subprogram, it would be necessary

5 to decode a symbol with use of reader 10 in order to observe the result of applying the editing commands. The efficiency and convenience advantages of the editing command simulation subprogram therefore should be clear to those skilled in the art.

10 An exemplary flow diagram for an editing command simulation subprogram is shown in Fig. 11E. At block 1214 processor 900 displays a message editing simulation screen or screens which allows a user to enter an unedited test message and symbology type (block 1216) and enter the type of editing
15 command desired to be applied to the message (block 1218). Three basic types of editing commands are search and replace editing commands, insert character editing commands, and delete character editing commands. Additional, more complex editing commands may also be applied.

20 When the commands are entered, processor 900 applies the commands entered at block 1218 to the unedited test message at blocks 1220, 1222, and 1224 if all are applicable. When editing is complete processor 900 outputs the result of applying the editing commands, at block 1226, typically by
25 displaying the edited message on display screen 930.

At block 1228 processor queries the user as to whether the user wishes to save the editing commands which resulted in the edited message being displayed or otherwise output at block 1226. If the user elects to save the editing commands,
30 then processor 900 at block 1230 writes the commands to a predetermined command save memory location associated with processor 900. When the parameter table editing subprogram described with reference to Fig. 11D is later executed the commands saved in block 1230 of the message editing command
35 subprogram may be read from the command save memory location

5 during execution of block 1192 of the parameter table editing subprogram.

In addition to being adapted to download new or modified operating programs to reader 10 remotely, processor 900 can also be adapted to remotely transmit component control
10 instructions to reader 10 which are executed by reader processor 40 substantially on receipt by reader 10 to control one or more components of reader 10 in a manner that can be perceived by a reader operator. For example, processor 900 and reader 10 can be arranged so that processor 900, on
15 receipt of a command from a user, transmits a component control instruction to reader 10 which is executed by reader processor 40 to have the same effect as trigger 52 being manually pulled, or alternatively, being released. Instructions transmitted by processor 900 having the same
20 effect as manually pulling and manually releasing trigger may be termed, respectively, "remote trigger activation" and "remote trigger release" instructions. Processor 900 and reader 10 can also be complementarily arranged so that, on receipt of a user activated command to remotely control reader
25 10, processor 900 transmits to reader 10 an instruction which is executed by reader 10 substantially on receipt of the instruction to turn on LED's 22 or to "flash" LED's according to a predetermined pattern, or to activate an acoustic output device such as speaker 38 to issue a "beep" or a series of
30 beeps. Component control instructions for on-receipt execution which operate to control LED's 22 or speaker 38 are useful, for example, to signal an alarm condition, to indicate that a task is completed, or to attract the attention of a reader operator for any purpose.

5 Processor 900 and reader 10 can also be complementarily
arranged so that, on receipt of a user activated command,
processor 900 transmits to reader 10 a component control
instruction which is executed by reader 10 substantially on
receipt thereof to transmit data which is stored in memory 45
10 or in another memory device associated with reader 10 such as
a long-term nonvolatile memory device. For example, a
component control instruction received from processor 900 may
be executed by reader 10 to upload from reader 10 to processor
900 image data that is stored in a specific memory location of
15 reader memory 45 such as a reader memory location that stores
the most recently captured image data captured by reader.
Processor 900 may subsequently display such uploaded image
data on display 930. Other component control instructions
which may be transmitted from processor 900 to reader 10 for
20 substantially on-receipt execution by reader processor 40 are
instructions which, for example, cause predetermined indicia
to be displayed by reader display 56, or which cause processor
40 to capture, by appropriate control over image sensor 32, a
single frame of image data corresponding to the scene
25 presently in the field of view of reader 10 in memory 45 or in
another memory device.

It will be understood that certain component control
instructions require that reader processor 40 execute a series
of instruction steps, or repetitive instruction steps to
30 cooperatively control more than one reader component. For
example, a component control instruction commanding an optical
reader to capture an image normally requires that processor 40
execute a series of instruction steps involving control of
such components as LED's 22, components of the imaging
35 assembly, and memory 45.

5 A modified reader operating program that adapts a reader to receive component control instructions from a remote local host processor for substantially on-receipt execution by reader 10 is shown in Fig. 6B. Reader 10 is readily enabled to receive and execute remote component control instructions
10 by modification of the program loop indicated by block 605 of Fig. 6A wherein reader 10 waits in a low power state until a trigger is pulled. As shown by the flow diagram of Fig. 6B, block 605 may be modified to the form illustrated by block 605' so that reader executes block 610 and the ensuing blocks
15 shown and described in connection with Fig. 6A in response either to a trigger being manually pulled or to the receipt of a remote trigger activation instruction from processor 900. Block 635 of the flow diagram of Fig. 6A may also be modified so that the reader is responsive either to a manual trigger
20 release or to receipt of a remote trigger receive instruction. Reader 10 may also be made to exit the loop indicated by block 605' on the condition that another component control instruction for on-receipt execution by reader 10 is received. As is indicated by block 602 and block 603, reader 10 may be
25 adapted to exit the loop indicated by block 605' and to appropriately control the component associated with the received instruction on the condition that a remote component control instruction is received from processor 900.

30 Scanning-Decoding/Autodiscrimination

The scanning-decoding and autodiscrimination features of the invention, and their relationships to the above-described menuing and reprogramming features, will now be described with reference to Figs. 6 and 12 - 18. More
35 particularly, the combined operation of these features will be

5 discussed in connection with Fig. 6A. The SOD, SS and DOD
scanning-decoding modes of the invention will be discussed in
connection with Figs. 13 and 14, and the OS, RUD and RUS
scanning-decoding modes of the invention will be discussed in
connection with Fig. 15. Finally, the 1D and 2D portions of
10 the autodiscrimination feature of the invention will be
discussed in connection with Figs. 16-18, respectively.

Turning first to the main program of Fig. 6A, the
scanning and decoding operations are shown as blocks 625-647.
In those embodiments or modes in which the multiple symbols
15 code option is not enabled (see option B5 of Fig. 7B), the
processor assumes, that only one symbol is to be decoded.
Under this condition, if decoding is successful, the processor
processes the decoded symbol as a menu symbol in accordance
with previously described menu routine 660, or as output data
20 in accordance with block 646, and then is stopped by one of
blocks 647, 635 or 642. If decoding is not successful, the
processor is directed back (unless stopped by blocks 635 or
642) to capture and attempt to decode another image. In this
case, the "no" output of multiple symbols block 643 is
25 selected, allowing additional images to be captured as
necessary.

In those embodiments or modes in which the multiple
symbols option is enabled, the processor assumes that more
than one symbol is present in the image data. Under this
30 condition, if decoding is successful, the processor continues
to loop back to block 627 to make additional decoding
attempts, unless stopped by one of blocks 635 or 642. In this
case, however, the "yes" output of block 643 is selected,
preventing additional images from being captured.

5 When the processor begins executing its scanning-
decoding program, it first determines from the parameter table
which scanning-decoding option or combination of options is to
be used. It will then be directed to an autodiscrimination
routine that is configured to execute that routine in
10 accordance with the selected scanning-decoding option or
options.

 At start up, the parameter table maybe set up so that
operation in the One Shot scanning-decoding mode is
established as a default condition. Alternatively, the
15 parameter table may be set up so that the RUD or RUS scanning-
decoding mode is established as a default condition. Since
the One Shot mode is inherently a non-tracking mode, its
selection as a default mode implies that none of the tracking
modes is selected. Since the RUD and RUS modes can be used
20 either with or without one of the three tracking modes, its
selection as a default parameter may or may not be associated
with one of the three tracking modes, depending upon how the
reader is programmed at the time of manufacture.

25 (a) Tracking Options

 The differences between the three tracking modes of the
invention are best understood with reference to Figs. 12-14.
The latter figures (with changes in figure and indicia number)
are incorporated from prior copending U.S. Patent Application
30 Serial No. 08/914,833, together with their associated
descriptions as follows:

 Scanning of indicia can take place under either of two
generalized conditions, depending upon the decoding load
presented by the indicia. Under light decoding loads, shown
35 in Fig. 12A for a prior art reader, the amount of data to be

5 decoded is relatively small, allowing scan data from a
complete scan to be decoded in a time which is less than the
duration of a scan. Under this condition, the result of each
scan is decoded before the completion of the following scan,
and no problems arise as a result of any mismatch between the
10 scan time and the decode time of the reader. The prior art
and the instant invention perform equally well under such
light decoding loads as will be seen later from Fig. 13.

Under heavy decoding loads, however, prior art methods
do not allow sufficient time for decoding. Thus, as shown in
15 Fig. 12B, when a first scan, Scan 1 is completed, a second
scan, Scan 2 is initiated immediately. Scan 2 is then
followed by Scan 3 while the decoding of Scan 1 is still in
progress. As this situation continues, the decoding process
will be seen to fall further and further behind the scanning
20 process until, at some point, the data memory becomes filled.
When this occurs new scan data will overwrite old scan data
which was not processed, thereby causing a loss of large
blocks of scan data.

In the embodiment of the invention disclosed in prior
25 copending Application Serial No. 08/205,539, now issued as
U.S. Patent No. 5,463,214, this problem is solved by modifying
the reader in a way that allows the scanning process to be
suspended and restarted as required to prevent the decoding
process from falling so far behind the scanning process that
30 data overflows the memory and is lost. This embodiment is
referred to herein as the "Scan on Demand" or SOD tracking
mode. This solution to the problem may be understood with
reference to Figs. 13A and 13B. Referring to Fig. 13A, there
is shown the operation of the subject embodiment of the
35 invention under light decoding loads. It will be noted that,

5 under this condition, the relationship between scanning and decoding is the same as that shown in Fig. 12A.

Fig. 13B shows the relationship which exists between the scanning and decoding processes when the Scan On Demand mode of the invention is used under heavy decoding loads. As
10 shown in Fig. 13B, the suspension of the scanning process continues until the results of the prior scan have been decoded. This prevents the decoding process from falling more than a small amount of time behind the scanning process. As a result, there cannot arise a situation, such as that which can
15 arise with the prior art, in which there is a massive loss of scan data. Because this process is described in detail in U.S. Patent No. 5,463,214, it will not be described in detail herein.

Referring to Fig. 13C there is shown the tracking
20 relationship which exists between the scanning and decoding operations when these operations are controlled in accordance with a tracking mode referred to as the "Skip Scan" or SS tracking mode. With this mode, under heavy decoding loads, decoding proceeds without interruption so long as the scanning
25 function is called for. As shown in Fig. 13C, each decoding operation begins immediately after the preceding decoding operation ends, and proceeds on the basis of the scan data from the then most current complete block of scan data.

More particularly, Fig. 13C illustrates one possible
30 scenario in which decoding of Scan 1 data is immediately followed by the decoding of Scan 2 data. This occurs because Scan 3 data is incomplete at the time that the second decoding operation begins. The decoding of Scan 2 data, however, is immediately followed by the decoding of Scan 5 data. This
35 occurs because Scan 5 data represents the then most current

5 complete block of scan data. While the results of scans 3 and
4 are therefore unused and skipped over, the data lost by
their non-use is provided by more current scan data or, if
decoding is unsuccessful, by the results of a later scan. Any
occasional decoding failure that results from the skipping of
10 relatively old blocks of scan data is in any case more than
offset by the avoidance of the large scale data losses
discussed in connection with Fig. 12B.

Referring to Fig. 13D there is shown the tracking
relationship which preferably exists between the scanning and
15 decoding operations when these operations are performed in a
reader which includes two and only two scan data memory spaces
A and B. With this reader, the preferred tracking mode is the
"Decode on Demand" or DOD tracking mode. With this mode
decoding does not proceed without interruption. As shown in
20 Fig. 13D, each decoding operation begins at the beginning of a
block of scan data. In the event that the end of a decoding
operation does not coincide with the beginning of such a
block, i.e., occurs while a scanning operation is still in
progress, the beginning of the next decoding operation will be
25 delayed until the scanning operation that is then in progress
is completed, and then proceeds with reference to the block of
scan data which is produced by that scanning operation.

More particularly, Fig. 13D shows that the decoding of
Scan 1 data is completed while Scan 3 is still in progress,
30 overwriting data for Scan 2. Under this condition, decoding
is discontinued for a time period T_{s1} that is equal to the time
necessary for Scan 3 to be completed. At the end of time
period T_{s1} , decoding resumes with the then most current block
of scan data, namely: the scan data produced during Scan 3.
35 Thus, like the mode which is illustrated Fig. 13C, the mode

5 which is illustrated in Fig. 13D begins its decoding operation with the then most current complete block of scan data.

Referring to Fig. 13E, there is shown the tracking relationship which exists between the scanning and decoding operations when these operations are performed in a reader
10 which includes three scan data memory spaces A, B and C. With this embodiment decoding proceeds without interruption so long as the scanning function is called for. As shown in Fig. 13E, each decoding operation begins immediately after the preceding decoding operation ends, and proceeds on the basis of scan
15 data from the memory which contains the then most current complete block of scan data.

More particularly, Fig. 13E shows that the decoding of Scan 1 is completed while Scan 3 is still being acquired. Under this condition, with three memory spaces available,
20 decoding is immediately undertaken on the most recent complete Scan (Scan 2) which is contained in memory space B. Upon the completion of the decoding of Scan 2, decoding is commenced on Scan 4 which is contained in memory space A. Thus, the utilization of three memory spaces allows the decoding portion
25 of the invention to be occupied one hundred percent of the time.

The mode illustrated in Fig. 13C is best suited for use with readers having memories and addressing procedures which can accommodate large numbers of relatively short blocks of
30 scan data having sizes that are not known in advance. Applications of this type typically include readers, such as that shown in Fig. 3, which use 1D image sensors.

The modes illustrated in Figs. 13D and 13E, on the other hand, are best suited for use with readers having
35 memories and addressing procedures which can accommodate small

5 numbers of relatively long blocks of scan data of fixed
length. Applications of these types typically include
readers, such as that shown in Fig. 2, which use 2D image
sensors. With the embodiment illustrated in Fig. 13D, only
two scan data memory spaces are used and decoding is
10 discontinuous. With the embodiment illustrated in Fig. 13E
three scan data memory spaces are used and decoding is
continuous. More than three scan data memory spaces can also
be used if additional decoding resources are made available.
The one of these different embodiments which is used in a
15 particular application is a design choice which is based on
economic considerations.

The fact that some embodiments of the invention use 1D
image sensors while others use 2D image sensors should not be
taken to mean that embodiments which use 1D image sensors can
20 only read 1D symbols or that embodiments which use 2D image
sensors can only read 2D symbols. This is because techniques
exist for using either type of image sensor to read both 1D
and 2D symbols. It will therefore be understood that the
present invention is not restricted to use with any one type
25 of image sensor or to any one type of bar code or other
optically encoded symbol.

Referring to Fig. 14A, there is shown a memory space M1
suitable for use in storing blocks of scan data of the type
produced by a reader with a 1D image sensor, together with a
30 pointer or tracking memory M2 suitable for use in storing
address or pointer information that makes it possible for the
reader to identify the beginning and end point of a block of
interest. As shown in Fig. 14A, the block of scan data
produced during a first scan of the target is stored in memory
35 M1 beginning at address SS1 (Scan Start for Scan 1) and ending

5 at address SE1 (Scan End for Scan 1). Similarly, the block of scan data resulting from a second scan of the target is stored between addresses SS2 and SE2, and so on. Because scanning takes place continuously, the end of one scan block (e.g. SE1) coincides with the beginning of the next scan block (e.g.,
10 SS2). The sizes (in memory space) of these blocks will ordinarily vary from block to block, depending on the number of data transitions in each 1D scan of the target. The boundaries between blocks will, however, be fixed by the occurrence times of the Scan Interrupt signals which are
15 generated by the image sensor or its clock generating circuitry.

Locations SS and SE of memory M2 are updated in the course of a series of scans so that they always identify or otherwise point to the address of the beginning and ending of
20 the most recently produced complete block of scan data. As a result, when the decoding circuitry is ready to decode the most recently produced complete block of scan data, it need only refer to locations SS and SE to obtain information as to where to begin and end decoding. Before decoding begins, the
25 contents of locations SS and SE are written into locations DS (Decode Start) and DE (Decode End) so that locations SS and SE can continue to be updated while decoding proceeds on the basis of the contents of locations DS and DE. In the preferred embodiment, the decoding circuitry is programmed to
30 mark these beginning addresses as "invalid" (for example, by changing its sign) after it is acquired. Since the decoding processor is programmed to decode only "valid" data, this assures that it can decode a single block of scan data only once.

5 Referring to Fig. 14B there are shown a plurality of
memory spaces MA, MBMN suitable for use in storing blocks
of scan data of the type produced by a reader having a 2D
image sensor, together with a pointer or tracking memory MP
suitable for use in storing address or pointer information for
10 identifying the memory spaces to be used for entering new scan
data, decoding, etc. Since the amount of scan data in each
block of scan data is known in advance, being the same for
each scan, the starting and ending addresses for each memory
space (e.g., A_1 and B_1 and A_N and B_N , etc.) will also be the
15 same for each scan. As a result, the memory to be used for
storing new scan data, decoding etc. may be specified by
specifying just a few bits stored in memory MP. Location CS,
for example, may be used as a pointer which identifies the
memory where the current scan is being stored, and location NS
20 may be used as a pointer which identifies where the next
scanned image is to be stored.

Similarly, location CD may be used as a pointer which
identifies the memory space where the current decode is being
undertaken. Finally, location ND may be used as a pointer
25 which identifies where the next available image is for
decoding purposes.

Under ordinary circumstances, three scan data memory
spaces will be sufficient to keep the decoding activity of the
reader fully occupied and current. This is because the
30 tracking method of the invention allows the skipping over of
old blocks of scan data as necessary for the decoder to remain
occupied and current. If the decoding load becomes extremely
heavy, however, it is possible that more old blocks of scan
data are skipped over than is advisable. In such instances,
35 it may be desirable to increase the number of memory spaces

5 from 3 to N, where N may be 4 or even more, and to use more
than one decoding circuit. If such an increased number of
memories and decoders is used, blocks of scan data may be
distributed among the memories according to a simple
sequential rule and kept track of by increasing the number of
10 bits in the pointers of memory space MP. In addition, the
decoding circuits may be assigned to the then most current
complete block of scan data as they become free. It will be
understood that all such numbers of memory spaces and decoding
circuits and the associated tracking procedure are within the
15 contemplation of the present invention.

Referring to Fig. 15, there is shown a simplified
version of Fig. 6A which eliminates those blocks which do not
relate directly to the use of the scanning-decoding parameters
of Fig. 7B to produce decoded output data. Of the blocks
20 shown in Fig. 15, blocks 625, 627, and 646 are common to prior
art readers and to readers constructed according to the
present invention. The remaining blocks of Fig. 15 operate
either singly or in various combinations to establish the
permitted combinations of the scanning-decoding modes shown in
25 Fig. 7B. These remaining blocks together comprise the
preferred embodiment of the means by which the reader of the
invention is controlled in accordance with the scanning-
decoding relationships called for by the parameter table
thereof. Other combinations of flow chart blocks, and other
30 combinations of scanning-decoding parameters may also be used,
however, without departing from the present invention. Blocks
642 and 643 may, for example, be configured so that only a
preset number of multiple symbols or a preset number of
repeats is permitted. Alternatively, all scanning-decoding
35 control blocks may be collectively replaced by a look-up table

5 which directly specifies the next action to be taken. These
and other variants will be understood to be within the
contemplation of the present invention.

In view of the foregoing, it will be seen that the
scanning and decoding processes of the invention may have a
10 selectable one of any of a plurality of different
relationships with one another, some of these relationships
being tracking relationships and some being non-tracking
relationships. In accordance with the invention, the menuing
feature of the invention allows a user to select that
15 operating mode, whether or not tracking, which gives the best
overall data throughput rate in view of the user's then
current objectives.

(b) Autodiscrimination/Code Options

20 The manner in which the code options called for by the
parameter table of the invention are implemented in
conjunction with the autodiscrimination feature of the
invention, will now be described with reference to the flow
charts of Figs. 16 and 18. Generally speaking, the flow chart
25 of Fig. 16 illustrates the 1D portion of a complete 1D/2D
autodiscrimination process, while the flow chart of Fig. 18
illustrates the 2D portion of a complete 1D/2D
autodiscrimination process. If both the 1D and 2D code
options of the parameter table are enabled (see options B1 and
30 B2 of Fig. 7B), the steps called for by both Figs. 16 and 18
will be executed before the autodiscrimination process is
completed. If, however, only one or the other of the 1D and
2D code options of the parameter table is enabled, only the
steps called for by Fig. 16 or by Fig. 18 will be executed
35 before the autodiscrimination process is completed. It will

5 therefore be seen that the menuing features and the
autodiscrimination
features of the present invention interact with one another in
a manner that allows a user to tailor the autodiscrimination
circuitry as necessary to achieve the highest possible data
10 throughput rate for a particular application.

In order to gain an understanding of the present
invention as a whole, it should be borne in mind that the
above-described relationships between the decoding and menuing
processes of the invention exist as a subset of an even more
15 complex set of relationships that include the tracking and
multiple symbols features of the invention. When, for
example, a portion of the flow chart of Figs. 16 and 18 calls
for an attempted decode, it must be remembered that the
attempted decode takes place in the context of the tracking or
20 non-tracking relationships indicated by the parameter table
options. In addition, the number of passes that the processor
makes through the flow chart of Fig. 16, before continuing on
to the flow chart of Fig. 18, depends upon whether or not the
multiple symbols feature of the invention has been enabled.

25 In principle, at least, each one of the possible
combinations of the above-described options may be represented
in a complete and separate flow chart and described as such.
Because adopting the latter approach would obscure rather than
clarify the present invention, however, the present
30 application will describe these combinations simultaneously in
terms of a representative flow chart, with different options
being described potential variants of that representative flow
chart.

Turning first to the flow chart of Fig. 16, there is
35 shown the 1D portion of the autodiscrimination process, which

5 operates on a set of image data that has been scanned from a target symbol of unknown type and orientation and stored in RAM 45. If the reader is a 2D reader, this image data will comprise a gray scale representation of the 2D image formed on the image sensor, each pixel of the image sensor being
10 represented by an image data element that includes an 8 bit gray scale indication of its brightness. If, on the other hand, the reader is a 1D reader, the image data may comprise either binary or gray scale values.

If the reader includes a 2D image sensor, this image
15 data will have been scanned as a 2D image while the reader is held substantially stationary with respect to its target. If the reader includes a 1D image sensor this image data will have been scanned as a series of 1D images while the reader is being moved asynchronously across the target in the manner
20 described in copending commonly assigned U.S. Patent Application Serial No. 08/504,643, which is expressly incorporated herein by reference.

On encountering block 1605, the processor is directed to calculate the "activities" of selected image data elements.
25 The "activity" of a point P as used herein comprises a measure of the rate of change of the image data over a small two dimensional portion of the region surrounding point P. This activity is preferably calculated along any two arbitrarily selected directions which are mutually perpendicular to one
30 another, as shown by the lines parallel to directions X and Y of Fig. 17A. One example of an activity calculation is that which is based on the squares of the gray scale differences of two pairs of points P1X - P2X and P1Y - P2Y that are centered on point P, as shown in Fig. 17A. Two mutually perpendicular
35 directions are used because the orientation of the symbol is

5 unknown and because a high activity level that by chance is
difficult to detect in a first direction will be readily
detectable in a second direction perpendicular to that first
direction.

10 In the preferred embodiment, an activity profile of the
image data is constructed on the basis of only a selected,
relatively small number of image data elements that are
distributed across the field of view that corresponds to the
stored image data. Using a relatively small number of data
elements is desirable to increase the speed at which the
15 symbol may be imaged. These selected points may be selected
as the points which lie at the intersections of an X-Y
sampling grid such as that shown in Fig. 17A. The spacing of
the lines defining this grid is not critical to the present
invention, but does affect the resolution with which the
20 activity profile of the image can be measured.

When the processor has determined the activities of the
selected image data points, it is directed to block 1610,
which causes it to look for candidate bar code symbols by
identifying regions of high activity. This is conveniently
25 done by determining which sets of image data points have
activities that exceed a predetermined activity threshold
value. A simplified, one-dimensional representation of this
step is illustrated in Fig. 17B, wherein those image data
points having an activity that exceed a threshold value TH are
30 labeled as a candidate symbol region CSR1.

In embodiments which are adapted to find and decode all
of the symbols that occur in fields of view that include a
plurality of bar code symbols, (i.e., embodiments in which the
multiple symbols option is enabled), the result of the step
35 called for by block 1610 is the identification of a plurality

5 of candidate symbol regions (CSRs), any one or more of which
may be a bar code symbol. Whether or not they are bar code
symbols is determined on the basis of whether they are
decodable. As will be explained more fully later, if the
multiple symbols option is not enabled, the processor may be
10 instructed to select one of the CSRs according to a suitable
selection rule, such as the largest CSR first, the CSR nearest
the center of the field of view first, the CSR with the
highest total activity first, etc., and then attempt to decode
only that symbol and stop, whether or not a symbol has been
15 decoded. Alternatively, as a further option, the processor
may be instructed to attempt to decode each CSR in turn until
one of them is successfully decoded, and then stop. If the
multiple symbols option is enabled, the processor will process
all of the CSRs, in turn, according to a suitable priority
20 rule, and continue to do so until all of the CSRs have been
either decoded or have been determined to be undecodable.

Once all CSRs have been located, the processor is
directed to block 1615, which calls for it to select the then
largest (or most centrally located) as yet unexamined CSR for
25 further processing, and then proceed to block 1620. The
latter block then causes the processor to find the centroid or
center of gravity of that CSR, before proceeding to block
1625. An example of such a centroid is labeled C in Fig. 17C.
Because the steps involved in finding a centroid are well
30 known, they will not be described in detail herein.

On encountering block 1625, the processor is directed
to examine the selected CSR by defining various exploratory
scan lines therethrough, determining the activity profile of
the CSR along those scan lines, and selecting the scan line
35 having the highest total activity. In the case of a 1D bar

5 code symbol, this will be the direction most nearly perpendicular to the direction of the bars, i.e., the optimum reading direction for a 1D symbol.

On exiting block 1625, the processor encounters blocks 1630 and 1635. The first of these sets a scan line counter to
10 zero; the second defines an initial, working scan line through the centroid in the previously determined direction of highest activity. The result of this operation is the definition, in the image data space representation of the CSR, of a working scan line such as SC=0 in Fig. 17C.

15 Once the initial scan line has been defined, the processor is directed by block 1640 to calculate, by interpolation from the image data of the CSR, the values of sampling points that lie along this scan line. This means that, for each sampling point on the initial scan line, the
20 processor will calculate what brightness the sampling point would have if its brightness were calculated on the basis of the weighted brightness contributions of the four nearest measured image data points of the CSR. These contributions are illustrated by the dotted lines which join the sample
25 point SP of Fig. 17D to the four nearest image data points DPA-DPD. So long as these sampling points are more closely spaced than the image data points, this interpolation procedure will be performed on a subpixel basis, and will produce a usably accurate representation of the image data
30 along the scan line. The result of the subpixel interpolation of the sampling points on a representative scan line of this type is shown in Fig. 17E. Because the particulars of the subpixel interpolation process are known to those skilled in the art, this process will not be further described herein.

5 Once the above-described scan line data have been
calculated, the processor is directed to block 1645, which
calls for it to binarize the scan line data, i.e., convert it
to a two-state representation of the data which can be
processed as a candidate for 1D decoding. One such
10 representation is commonly known as a timercount
representation. One particularly advantageous procedure for
accomplishing this binarization process is disclosed in U.S.
Patent No. 5,286,960, which is hereby incorporated herein by
reference.

15 On exiting block 1645, the processor will be in
possession of a potentially decodable two-state 1D
representation of the CSR. It then attempts to decode this
representation, as called for by block 1650. This attempted
decoding will comprise the trial application to the
20 representation of one 1D decoding program after another until
the latter is either decoded or determined to be undecodable.
Because decoding procedures of the latter type are known to
those skilled in the art, they will not be discussed in detail
herein.

25 As the 1D autodiscrimination process is completed, the
processor is directed to decision block 1655 which causes it
to continue along one of two different paths, depending on
whether or not decoding was successful. If it was not
successful, the processor will be caused to loop back to block
30 1635, via blocks 1660 and 1665, where it will be caused to
generate a new working scan line that is parallel to initial
scan line SC=0, but that passes above or below centroid C.
This looping back step may be repeated many times, depending
on the "spacing" of the new scan lines, until the entire CSR
35 has been examined for decodable 1D data. If the entire CSR

5 has been scanned and there has been no successful decode, the processor is directed to exit the just-described loop via block 1670. As used herein, the term "parallel" is used in its broad sense to refer to scan lines or paths which are similarly distorted (e.g., curvilinear) as a result of
10 foreshortening effects or as a result of being imaged from a non-planar surface. Since compensating for such distorting effects is known, as indicated, for example, by U.S. Patent No. 5,396,054, it will not be discussed in detail herein.

Block 1670 serves to direct the processor back to block
15 1615 to repeat the above-described selection, scanning and binarizing steps for the next unexamined CSR, if one is present. If another CSR is not present, or if the processor's program calls for an attempt to decode only one CSR, block 1670 causes the processor to exit the flow chart of Fig. 16 to
20 begin an attempt to decode the then current set of image data as a 2D symbol, in accordance with the flow chart of Fig. 18. If other CSRs are present, and the multiple symbols option is enabled, block 1670 directs the processor back to block 1615 to repeat the selection, scanning and binarizing process for
25 the next CSR, and the next, and so on, until there is either a successful decode (block 1655) or all of the CSRs have been examined (block 1670).

If the processing of the first CSR has resulted in a successful decode, block 1655 directs the processor to block
30 1675, which causes it to determine whether the decoded data indicates that the CSR contains a 1D stacked symbol, such as a PDF417 symbol. One example of such a symbol is shown in Fig. 19D. If it is not, i.e., if the decoded symbol includes only a single row of bars, the 1D data is stored for later
35 outputting in accordance with block 648 of the main program of

5 Fig. 6A, as called for by block 1680. Alternatively, the data
may be output immediately and block 648 later skipped over.
Then, if there are no remaining unexamined CSRs, or if the
multiple symbols option is not enabled, the processor is
directed to exit the flow chart of Fig. 16 via block 1682.

10 If, however, there are remaining CSRs and the multiple symbols
option is enabled, block 1682 will direct the processor back
to block 1615 to begin processing the next CSR, and the next,
and so on until all CSRs have been examined and decoded (block
1682) or examined and found to be undecodable (block 1670).

15 If, on encountering block 1675, the decoded data
indicates that the CSR contains a 1D stacked symbol, the
above-described processing is modified by providing for the
repetition of the scanning-digitizing process, beginning with
block 1635. This is accomplished by blocks 1684, 1686 and
20 1688 in a manner that will be apparent to those skilled in the
art. Significantly, by beginning the repeating of the process
at block 1635, all additional scan lines defined via the
latter path will be parallel to the first decodable scan line,
as required by a 1D stacked symbol, at least in the broad
25 sense discussed earlier.

In view of the foregoing, it will be seen that,
depending on the number of CSRs that have been found in the
stored image data, and on the enablement of the multiple
symbols option, the flow chart of the embodiment of the
30 invention shown in Fig. 16 will cause all 1D symbols in the
image data to be either decoded or found to be undecodable
before directing the processor to exit the same.

As will be explained more fully in connection with Fig.
20, the 2D autodiscrimination flow chart of Fig. 18 may be
35 processed after the processing of the 1D autodiscrimination

5 flow chart of Fig. 16 has been completed. It may also be
processed without the flow chart of Fig. 16 having been
previously processed, i.e., the 1D portion of the 1D/2D
autodiscrimination process may be skipped or bypassed. (In
principle, the steps of the 2D portion of the 1D/2D
10 autodiscrimination process (Fig. 18) may also be processed
before the 1D portion thereof (Fig. 16), although this option
does not comprise the preferred embodiment of the invention).
This is because the code options of the menuing feature of the
invention make all of these options selectable by the user.
15 It will therefore be understood that the present invention
contemplates all possible combinations of autodiscrimination
options.

Referring to Fig. 18, there is shown a flow chart of
the 2D portion of the 1D/2D autodiscrimination process of the
20 invention. When the flow chart of Fig. 18 is entered, the
image data that is stored in RAM 45 is the same as that which
would be stored therein if the flow chart of Fig. 16 were
being entered. If the reader is a 2D reader this image data
will comprise an array of 8-bit gray scale image data elements
25 produced by image sensor 32-2 and its associated signal
processing and A/D converter circuits 3502 and 36-2. If the
reader is a 1D reader that produces a 2D image by being moved
across the target symbol, the image data will comprise an
array of binary data elements such as those shown in above-
30 cited copending Application Serial
No. 08/504,643.

The flow chart of Fig. 18 begins with a block 1805,
which directs the processor to convert the gray scale image
data representation stored in RAM 45 (if present) into a two-
35 state or binarized representation of the same data. This may

5 be accomplished in generally the same manner described earlier
in connection with Fig. 17B, i.e., by comparing these gray
scale values to a threshold value and categorizing these
values as 1s or 0s, depending upon whether they exceed or do
not exceed that threshold value.

10 Once the image data has been binarized, the processor
continues on to block 1810, which causes it to identify and
locate all of the 2D finder patterns that appear in the field
of view of the image data. This is preferably accomplished by
examining all of the candidate 2D finder patterns (CFPs) that
15 are present and identifying them by type, i.e., identifying
whether they are bullseye type finder patterns, waistband type
finder patterns or peripheral type finder patterns. An
example of a bullseye type finder pattern is shown in the
central portion of the 2D bar code symbol of Fig. 19A, which
20 symbol encodes data in accordance with a 2D matrix symbology
named "Aztec". An example of a waistband type finder pattern
is shown in the middle portion of the 2D bar code symbol of
Fig. 19B, which symbol encodes data in accordance with a 2D
matrix symbology named "Code One". An example of a peripheral
25 type finder pattern is shown in the left and lower edges of
the 2D bar code symbol of Fig. 19C, which symbol encodes data
in accordance with a 2D matrix symbology known as "Data
Matrix". The finder identification process is performed by
applying to each CFP, in turn, a series of finder pattern
30 finding algorithms of the type associated with each of the
major types of finder patterns. Since such finder finding
algorithms are known for finders of the waistband and
peripheral types, these algorithms will not be discussed in
detail herein. One example of a finder finding algorithm for
35 a waistband type finder, may be found, for example, in

5 "Uniform Symbology Specification Code One", published by
AIM/USA Technology Group. Finder finding algorithms for
bullseye type finders that include concentric rings, (e.g.
MaxiCode) are also known and will also not be described in
detail herein.

10 Particularly advantageous for purposes of the present
invention, however, is bullseye type finder finding algorithm
of the type that may be used both with 2D symbologies, such as
MaxiCode, that have bullseye finder patterns that include
concentric rings and with 2D symbologies, such as Aztec, that
15 have bullseye finder patterns that include concentric
polygons. A finder finding algorithm of the latter type is
described in copending, commonly assigned U.S. Patent
Application Serial No. 08/504,643, which has been incorporated
herein by reference. The Aztec 2D bar code symbology itself
20 is fully described in U.S. Patent Application Serial No.
08/441,446, which has also been incorporated herein by
reference.

Once all of the finder patterns have been located and
their types have been determined, the processor is directed to
25 decision block 1815. This block affords the processor an
opportunity to exit the flow chart of Fig. 18, via exit block
1820, if no 2D finder patterns could be found and typed. This
block speeds up the execution of the program by skipping over
decoding operations which have no hope of success without
30 their associated finder pattern.

If a finder pattern has been found and typed, the
processor is directed to block 1825. This block causes the
processor to select for decoding the bar code symbol whose
finder is closest to the center of the field of view of the
35 image data. Optionally, the processor may be instructed to

5 find the largest 2D bar code symbol that uses a particular 2D
symbolology or the 2D bar code symbol using a particular 2D
symbolology which is closest to the center of the field of view
of the image data. The "closest-to-the-center" option is
ordinarily preferred since a centrally located symbol is
10 likely to be a symbol, such as a menu symbol, at which the
user is deliberately aiming the reader. Once this selection
has been made, the processor attempts to decode that symbol,
as called for by block 1830. If this decoding attempt is
successful, as determined by decision block 1835, the
15 resulting data may be stored for outputting in accordance with
block 648 of the main program of Fig. 6A, as called for by
block 1840. Alternatively, the decoded data may be output
immediately and block 648 later skipped over. If the decoding
attempt is not successful, however, block 1840 is skipped, and
20 the processor is directed to decision block 1845.

If the user has elected not to use the multiple symbols
option, block 1845 may direct the processor to exit the flow
chart of Fig. 18, via block 1850, after any 2D symbol has been
successfully decoded. Optionally, block 1845 may be arranged
25 to direct the processor to exit the flow chart of Fig. 18
after the attempted decoding of the centermost symbol, without
regard to whether or not the decoding attempt was successful.

If the user has elected to use the multiple symbols
option, block 1845 will direct the processor back to block
30 1825 to process the next 2D symbol, i.e., the symbol whose CFR
is next closest to the center of the field of view. The
above-described attempted decoding and storing (or outputting)
steps will then be repeated, one CFR after another, until
there are no more symbols which have usable finder patterns.
35 Finally, when all symbols having usable finder patterns have

5 been either decoded or found to be undecodable, the processor
will exit the flow chart of Fig. 18, via block 1850, to return
to the main program of Fig. 6A.

In view of the foregoing, it will be seen that,
depending on the number of identifiable CFRs that have been
10 found in the stored, digitized image, and on the enablement of
the multiple symbols option, the 2D autodiscrimination routine
shown in Fig. 18, will cause one or more 2D symbols in the
image data to be either decoded or found to be undecodable
before directing the processor to exit the same.

15 For the sake of clarity, the foregoing descriptions of
the 1D and 2D phases of the 1D/2D autodiscrimination process
of the invention have been described separately, without
discussing the combined or overall effect of the code options
and scanning-decoding options discussed earlier in connection
20 with Fig. 7B. The overall effect of these code options and
the manner in which they are implemented will now be described
in connection with Fig. 20. As will be explained presently,
Fig. 20 shows (with minor simplifications) the contents of
block 627 of Fig. 6A. It also shows, as blocks 2010 and 2035
25 (again with minor simplifications), the 1D and 2D
autodiscrimination routines discussed earlier in connection
with Figs. 16 and 18, respectively.

On entering the flow chart of Fig. 20, the processor
encounters a block 2005 which causes it to determine, with
30 reference to the code options of the parameter table, whether
all of the 1D codes have been disabled. If they have not, the
processor continues to block 2010. In accordance with block
2010, the processor performs the 1D autodiscrimination process
described in connection with Fig. 16, using the 1D code and
35 scanning-decoding options indicated by the parameter table.

5 Depending upon whether 1D decoding was successful, as
determined by block 2015, the processor either outputs (or
stores) data per block 2020 and exits, or continues on to
blocks 2030 and 2035 to begin the 2D autodiscrimination
process.

10 If all 1D codes have been disabled, the processor is
directed directly to block 230, thereby skipping block 2010 in
its entirety. Then, unless all 2D codes have also been
disabled (per block 2030), it proceeds to block 2035 to begin
the autodiscrimination process described in connection with
15 Fig. 18, using the 2D codes and scanning-decoding options
indicated by the parameter table. Depending upon whether 2D
decoding was successful, as determined by block 2040, the
processor either outputs (or stores) data, per block 2045, or
returns to the main program of Fig. 6A. Returning to the
20 latter then causes or does not cause further scans to be made
depending on the states of blocks 635 and 640 thereof.

In view of the foregoing, it will be seen that the
1D/2D autodiscrimination process of the invention may be
practiced in many different ways, depending upon the menuing
25 options that have been chosen by the user. Among these
menuing options, the code options increase the data throughput
rate of the reader by assuring that the processor does not
waste time trying to autodiscriminate and decode symbols which
it has been told are not present, or are not of interest. The
30 scan tracking options also increase the data throughput rate
of the reader by assuring that the scanning and decoding
phases of read operations both operate, to the extent possible
in view of the then current decoding load and decoding
options, at a 100% utilization rate. Even the multiple
35 symbols option also increases the data throughput rate of the

5 reader by either discontinuing the reading of symbols that are
not centered and therefore not of interest or speeding up the
processing of multiple symbols that are of interest. Thus,
for a processor with a given performance rating and a set of
decoding programs of given length, the apparatus of the
10 invention assures a higher overall data throughput rate than
has heretofore been possible.

While the present invention has necessarily been
described with reference to a number of specific embodiments,
it will be understood that the time spirit and scope of the
15 present invention should be determined only with reference to
the following claims.